Senior Design Report
for
ECE 477 – Spring 2008

submitted by
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May 5, 2008

PURDUE
UNIVERSITY
School of Electrical & Computer Engineering

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Course Description

Digital Systems Senior Design Project (ECE 477) is a structured approach to the development and integration of embedded microcontroller hardware and software that provides senior-level students with significant design experience applying microcontrollers to a wide range of embedded systems (e.g., instrumentation, process control, telecommunications, intelligent devices, etc.). The primary objective is to provide practical experience developing integrated hardware and software for embedded microcontroller systems in an environment that models one which students will most likely encounter in industry.

One of the unique features of this course is that each team gets to choose their own specific project (subject to some general constraints) and define specific success criteria germane to that project. In general, this approach to senior design provides students with a sense of project ownership as well as heightened motivation to achieve functionality.

Course web site: `http://cobweb.ecn.purdue.edu/~dsml/ece477`

Course Staff

Name	*Title / Role*	*E-mail Address*
Prof. David Meyer	Faculty / Project Advisor	meyer@purdue.edu
Dr. Mark Johnson	Faculty / Project Advisor	mcjohnso@purdue.edu
Karl Herb	Teaching Assistant / Project Consultant	kherb@purdue.edu
Mike Sorenson	Teaching Assistant / Project Consultant	mesorens@purdue.edu

Lecture Schedule / Course Calendar

Monday	Tuesday	Wednesday	Thursday	Friday
Jan 7	Jan 8 Course Introduction 9:30-10:20 EE 117	Jan 9 Module 1 Doc/Prop/TC 11:30-1:20 ARMS B071	Jan 10 Module 2 Digital Design 9:30-10:20 EE 117	Jan 11 Preliminary Proposal Due
Jan 14	Jan 15 Module 3 Packaging 9:30-10:20 EE 117	Jan 16 TCSP PSSCs 11:30-1:20 ARMS B071	Jan 17 Module 4 uC survey 9:30-10:20 EE 117	Jan 18 Final Proposal Due
Jan 21 MLK Day	Jan 22 Module 5 Emb Sys I/F 9:30-10:20 EE 117	Jan 23 Module 6 Pow Sup Des 11:30-1:20 ARMS B071	Jan 24 Module 6 Pow Sup Desi 9:30-10:20 EE 117	Jan 25
Jan 28	Jan 29 Module 7 Pass Cmp Sel 9:30-10:20 EE 117	Jan 30 TCSP Constr Anal 11:30-1:20 ARMS B071	Jan 31 Module 8 Doc Stnds 9:30-10:20 EE 117	Feb 1 Design Constraint Analysis Due
Feb 4	Feb 5 Module 9 PCB Design 9:30-10:20 EE 117	Feb 6 TCSP Packaging 11:30-1:20 ARMS B071	Feb 7 Module 10 Assem/Solder 9:30-10:20 EE 117	Feb 8 Packaging Design Due
Feb 11 Lab Notebook Evaluation	Feb 12 Module 11 Debugging 9:30-10:20 EE 117	Feb 13 TCSP Schematic 11:30-1:20 ARMS B071	Feb 14 Prep for Design Revs 9:30-10:20 EE 117	Feb 15 Preliminary Schematic and Design Narrative Due
Feb 18	Feb 19	Feb 20 TCSP PCB Design 11:30-1:20 ARMS B071	Feb 21	Feb 22 Preliminary PCB Layout and Design Narrative Due
Feb 25	Feb 26 Formal Design Reviews	Feb 27 Formal Design Reviews	Feb 28 Formal Design Reviews	Feb 29
Mar 3	Mar 4 Module 12 Software Des 9:30-10:20 EE 117	Mar 5 Progress Briefings 11:30-1:20 EE 063	Mar 6	Mar 7 Proof-of-Parts Final Schematic Final PCB Due
Mar 10 Spring Break	Mar 11 Spring Break	Mar 12 Spring Break	Mar 13 Spring Break	Mar 14 Spring Break
Mar 17 Midterm Peer Evaluation Due	Mar 18 Module 13 Patent Liab 9:30-10:20 EE 117	Mar 19 TCSP Software 11:30-1:20 ARMS B071	Mar 20	Mar 21 Software Design Narrative Due
Mar 24 Lab Notebook Evaluation	Mar 25 Module 14 Rel/Safe Anal 9:30-10:20 EE 117	Mar 26 TCSP Patent Liability 11:30-1:20 ARMS B071	Mar 27	Mar 28 Patent Liability Analysis Due
Mar 31	Apr 1 Module 15 Eth/Env Imp 9:30-10:20 EE 117	Apr 2 TCSP Reli & Safety 11:30-1:20 ARMS B071	Apr 3	Apr 4 Reliability and Safety Analysis Due
Apr 7	Apr 8	Apr 9 TCSP Eth/Env Imp 11:30-1:20 ARMS B071	Apr 10	Apr 11 Ethical and Enviro Impact Analysis Due
Apr 14	Apr 15	Apr 16 Progress Briefings 11:30-1:20 EE 063	Apr 17	Apr 18 User Manual Due
Apr 21	Apr 22 Prep for Final Presentations 9:30-10:20 EE 117	Apr 23 TCSP PSSC Demos 11:30-1:20 ARMS B071	Apr 24	Apr 25 ECE 270/362 Bonus Credit Presentations (by invitation)

Formal Design Reviews individually scheduled on February 26-28

Final Presentation Session will be Wednesday, April 30, 8:00 AM – 12:30 PM

Final Lab Notebook Evaluation, Archive CD, Confidential Peer Review, User Manual, Final Report, Poster, and Senior Design Report due April 28 at 5:00 PM

Design Project Specifications / Requirements

Work on the design project is to be completed in teams of four students. The design project topic is flexible, and each group is encouraged to pick a product that uses the strengths and interest areas of their group members. The design must have the following components:

- **Microprocessor:** To help make the project tractable, microprocessor choices will be limited to 68HC12, PIC, Rabbit, and Atmel variants. Development tools are readily available in lab to support these devices. Further, the devices themselves are relatively low cost and readily available.
- **Interface to Something:** Your embedded system must interface to some other device or devices. It could be a computer, or it could be some embedded device such as a Palm Pilot, telephone line, TV, etc. Some interface standards that could be used are: serial to a computer, parallel to a computer, Universal Serial Bus (USB), Firewire, Ethernet, Infrared (IR), Radio Frequency (RF), etc. This requirement has a large amount of freedom. To help with some of the more complex interfaces such as Ethernet, USB, or Firewire there are dedicated chips which encapsulate the lowest layers of the interface. This makes using these interfaces easier to handle but not necessarily trivial. Be sure to investigate the interface(s) you wish to utilize and make a reasonable choice. (NOTE: *Interfaces involving A.C. line current require special permission – see the instructor for details.*)
- **Custom printed circuit board:** Through the process of the design, each group will be required to draw a detailed schematic. From the schematic, a two-layer (maximum) printed circuit board will be created. Board etching will be processed by the ECE Department (the first one is "free", but any subsequent iterations are the team's responsibility). The team is then responsible for populating the board (solder the parts on the board), and for completing the final stages of debugging and testing on their custom board.
- **Be of personal interest to at least two team member:** It is very difficult to devote the time and energy required to successfully complete a major design project in which you and/or your team members have no personal interest. There are *lots* of possibilities, ranging from toys and games to "useful and socially redeeming" household items, like audio signal processors and security systems.
- **Be tractable:** You should have a "basic idea" of how to implement your project, and the relative hardware/software complexity involved. For example, you should not design an "internet appliance" if you have no idea how TCP/IP works. Also, plan to use parts that are reasonably priced, have reasonable footprints, and are *readily available*. Be cognizant of the prototyping limitations associated with surface mount components.
- **Be neatly packaged:** The finished project should be packaged in a reasonably neat, physical sound, environmentally safe fashion. Complete specification and CAD layout of the packaging represents one of the project design components.
- **Not involve a significant amount of "physical" construction:** The primary objective of the project is to learn more about *digital system* design, not mechanical engineering! Therefore, most of the design work for this project should involve digital hardware and software.

Project Proposal: Each group should submit a proposal outlining their design project idea. This proposal should not be wordy or lengthy. It should include your design objectives, design/functionality overview, and project success criteria. The five success criteria common to all projects include the following:

- Create a bill of materials and order/sample all parts needed for the design
- Develop a complete, accurate, readable schematic of the design
- Complete a layout and etch a printed circuit board
- Populate and debug the design on a custom printed circuit board
- Package the finished product and demonstrate its functionality

In addition to the success criteria listed above, a set of **five significant** *project-specific* success criteria should be specified. The degree to which these success criteria are achieved will constitute one component of your team's grade.

Forms for the preliminary and final versions of your team's project proposal are available on the course web site. Use these skeleton files to create your own proposal. Note that the proposal should also include assignment of each team member to one of the design components as well as to one of the professional components of the project.

Group Account and Team Webpage: Each team will be assigned an ECN group account to use as a repository for all their project documentation and for hosting a password-protected team web page. The team web page should contain datasheets for all components utilized, the schematic, board layout, software listings, interim reports, presentation slides, etc. It should also contain the individual lab notebooks for each team member as well as the progress reports (prepared in advance of the weekly progress briefings) for each team member. At the end of the semester, each team must submit a CD-ROM archive of the group account.

Design Review: Part way through the design process, there will be a formal design review. This is a critical part of the design process. In industry, this phase of the design process can often make or break your project. A good design review is one where a design is actively discussed and engineers present concur with the current or amended design. The design review is in some cases the last chance to catch errors before the design is frozen, boards are etched, and hardware is purchased. *A friend is not someone who rubber-stamps a design, but rather one who actively challenges the design to confirm the design is correct.*

Approach the design review from a top-down, bottom-up perspective. First, present a block diagram of your design and explain the functional units. Then drop to the bottom level and explain your design at a schematic level. Be prepared to justify every piece of the design; a perfectly valid answer, however, is applying the recommended circuit from an application note. If you do use a circuit from an application note, have the documentation on hand and be able to produce it. *Your grade for the design review will not be based on the number of errors identified in your design.* The best engineers make mistakes, and the purpose of the design review is to *catch them* rather than spend *hours of debugging later* to find them. The design review will be graded primarily on how well the group understands their design and the professionalism with which they present it.

To facilitate the design review process, the class will be split into subgroups that will meet at individually scheduled times. Both the presenters and the assigned reviewers will be evaluated.

Design Project Milestones

Each group is responsible for setting and adhering to their own schedule; however, there are several important milestones, as listed in the table below. Always "expect the unexpected" and allow for some buffer in your schedule. *Budget your time.* With proper budgeting, senior design can be a very rewarding and pleasant experience.

See course schedule for homework due dates.

Week	*Milestone*
1	Formulate project ideas Preliminary project proposal due
2	Research parts, create initial block diagram and initial BOM Final project proposal due
3	Order/sample parts, review/learn OrCad *Capture* and *Layout*
4	Create detailed BOM (including resistors, capacitors, etc.)
5	Draw preliminary schematic Prototype interface circuits
6	Finalize schematic Begin PCB layout Begin prototyping software with EVB/prototype
7	Finalize PCB layout for Design Review Continue software development Prepare for Design Review
8	Continue software development **DESIGN REVIEWS**
9	Incorporate changes/comments from Design Review **Proof-of-Parts due** **Final schematic due** **PCB file submission due**
10	Continue software development on EVB
11	PCBs arrive - begin populating/testing
11-15	Test PCB section-by-section as parts are added, porting software as you go - *add functions one-by-one so you know what it was that "broke" your code or your board when things stop working*
16	**PSSC Demos** Prepare for Final Presentation
Finals	**FINAL PRESENTATIONS**

Course Outcomes and Assessment Procedures

In order to successfully fulfill the course requirements and receive a passing grade, each student is expected to demonstrate the following outcomes:

(i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design and test a microcontroller-based digital system
(ii) an understanding of the engineering design process
(iii) an ability to function on a multidisciplinary team
(iv) an awareness of professional and ethical responsibility
(v) an ability to communicate effectively, in both oral and written form

The following instruments will be used to assess the extent to which these outcomes are demonstrated (the forms used to "score" each item are available on the course web site):

Outcome	*Evaluation Instruments Used*
(i)	Design Component Homework
(ii)	Individual Lab Notebooks
(iii)	Success Criteria Satisfaction (general *and* project-specific)
(iv)	Professional Component Homework
(v)	Formal Design Review, Final Presentation, and Final Report

Students must demonstrate basic competency in ***all*** the course outcomes, listed above, in order to receive a passing grade. Demonstration of Outcome (i) will be based on the satisfaction of the design component homework, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (ii) will be based on the individual lab notebook, for which a minimum score of **60%** will be required to establish basic competency. Demonstration of Outcome (iii) will be based on satisfaction of the **100%** of the general success criteria and a minimum of **60%** (3 out of 5) of the project-specific success criteria. Demonstration of Outcome (iv) will be based on the professional component homework, for which a minimum score of **60%** will be required on the final evaluation to establish basic competency. Demonstration of Outcome (v) will be based on the Design Review, the Final Presentation, and the Final Report. A minimum score of **60%** on the Design Review and a minimum score of **60%** on the Final Report and a minimum score of **60%** on the Final Presentation will be required to establish basic competency.

Since *senior design* is essentially a "mastery" style course, students who fail to satisfy all outcomes but who are otherwise passing (based on their NWP) will be given a grade of "I" (incomplete). The grade of "I" may subsequently be improved upon successful satisfaction of all outcome deficiencies. If outcome deficiencies are not satisfied by the prescribed deadline, the grade of "I" will revert to a grade of "F".

Course Grade Determination

Several "homeworks" will be assigned related to key stages of the design project. Some of the assignments will be completed as a team (1, 2, 7, 13, 15, 16, 17), two will be completed individually (8 and 14), and some will be completed by a selected team member (one from the set {4, 5, 6, 9} and one from the set {3, 10, 11, 12}).

1. Team Building and Project Idea
2. Project Proposal
3. Design Constraint Analysis and Component Selection Rationale
4. Packaging Specifications and Design
5. Hardware Design Narrative/Preliminary Schematic
6. PCB Design Narrative/Preliminary PCB Layout
7. PCB Submission, Final Schematic, and Parts Acquisition/Fit
8. Peer Review – Midterm
9. Software Design Narrative, and Documentation
10. Patent Liability Analysis
11. Reliability and Safety Analysis
12. Ethical/Environmental Impact Analysis
13. User Manual
14. Peer Review – Final
15. Senior Design Report
16. Final Report & Archive CD
17. Poster

Grade Determination: Your course grade will be based on team effort and your contributions:

TEAM COMPONENTS (40% of total) distribution of team component		**INDIVIDUAL COMPONENTS (60% of total) distribution of individual component**	
Design Review*	15%	Lab Notebook Evaluation*	20%
Final Presentation*	15%	Design Report* {4, 5, 6, or 9}	20%
Final Report & Archive CD* {16}	15%	Professional Report* {3, 10, 11, or 12}	20%
Project Success Criteria Satisfaction*	15%	Individual Contribution / Teamwork	20%
Final PCB, Schematic, and PoP {7}	15%	Class Participation / Attendance	12%
System Integration and Packaging	10%	Peer Evaluations - Design Review	2%
User Manual {13}	5%	Peer Evaluations - Final Presentation	2%
Senior Design Report {15}	5%	Confidential Peer Review - Midterm {8}	2%
Poster {17}	5%	Confidential Peer Review - Final {14}	2%

* items directly related to outcome assessment

Your **R**aw **W**eighted **P**ercentage (RWP) will be calculated based on the weights, above, and then "curved" (i.e., mean-shifted) with respect to the upper percentile of the class to obtain a **N**ormalized **W**eighted **P**ercentage (NWP). Equal-width cutoffs will then be applied based on the **W**indowed **S**tandard **D**eviation (WSD) of the raw class scores; the minimum **C**utoff **W**idth **F**actor (CWF) used will be 10 (i.e., the nominal cutoffs for A-B-C-D will be 90-80-70-60, respectively). Before final grades are assigned, the course instructor will carefully examine all "borderline" cases (i.e., NWP within 0.5% of cutoff). Once grades are assigned, they are **FINAL** and WILL NOT be changed. Note that **all** course outcomes must be demonstrated in order to receive a passing grade for the course.

Course Assessment Report

Course: ECE 477 **Submitted by:** D. G . Meyer
Term: Spring 2008 **Course PIC:** D. G. Meyer

1. *Were all course outcomes addressed during the administration of the course? If not, why not and what actions do you recommend to remedy this problem in future offerings of this* course?

   The following outcomes must be demonstrated to receive a passing grade in ECE 477:
   (i) an ability to apply knowledge obtained in earlier coursework and to obtain new knowledge necessary to design, build, and test a microcontroller-based digital system
   (ii) an understanding of the engineering design process
   (iii) an ability to function on a multidisciplinary team
   (iv) an awareness of professional and ethical responsibility
   (v) an ability to communicate effectively, in both oral and written form

   All of these outcomes were addressed and, as indicated below, all students enrolled during the Spring 2008 offering of ECE 477 successfully demonstrated each outcome.

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Average Outcome Scores and Outcome Demonstration Statistics for ECE 477 – 5/5/2008

Outcome # 1 Avg Score:   88.5%    Passed:  60/ 60 = 100.00%    Failed:   0/ 60 =   0.00%

Outcome # 2 Avg Score:   78.8%    Passed:  60/ 60 = 100.00%    Failed:   0/ 60 =   0.00%

Outcome # 3 Avg Score:   84.7%    Passed:  60/ 60 = 100.00%    Failed:   0/ 60 =   0.00%

Outcome # 4 Avg Score:   86.5%    Passed:  60/ 60 = 100.00%    Failed:   0/ 60 =   0.00%

Outcome # 5 Avg Score:   90.0%    Passed:  60/ 60 = 100.00%    Failed:   0/ 60 =   0.00%

Demonstrated all five outcomes based on primary assessement:  60/ 60 = 100.00%
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Remediation of Outcomes 1 and 4 was required for several students.

2. *Are the course outcomes appropriate?* Yes.

3. *Are the students adequately prepared for this course and are the course prerequisites and co-requisites appropriate? If not, explain.*

   For the most part, yes.

4. *Do you have any suggestions for improving this course? If so, explain.*

   The course staff members are very satisfied with the thorough outcome assessment strategy currently in place. Use of Tablet PCs for the purpose of maintaining on-line notebooks appeared to improve performance on the associated outcome (paper to be presented at ASEE Conference, Summer 2008).

Appendix A:

Senior Design Reports

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	1
Project Title	Sentinel Mark I

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Ilya Veygman	EE	Software, Hardware	May 2008
Alan Bernstein	EE	Software, Hardware	May 2008
Darshan Shah	EE	Hardware	May 2008
Ian Alsman	EE	Hardware, Mechanical	Dec 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Sentinel Mark I is an automated sentry turret capable of autonomous target detection, acquisition and neutralization, with an added option of manual override from a user interface. A remote control is also available to allow authorized personnel to shut down the turret's targeting systems without using the main user interface. The intended customer is either the military/law enforcement or recreational shooting sport enthusiasts.

The project is centered on a Freescale MC9S12XDP512 microcontroller, which is interfaced with several peripherals to achieve sentry turret functionality. These peripherals were chosen to best reach the five project-specific success criteria set at the beginning of the semester. The first is an ability to fire an automatic Airsoft weapon. To do this, the chip interfaces with a switching transistor through an optocoupler, which turns an electric motor driving the weapon on and off. The second is the ability to sense off-camera motion using ancillary sensors. To achieve this, three passive infrared (PIR) motion sensors are interfaced via GPIO pins. The third is an ability to prevent friendly fire, which is achieved with an infrared remote control. To do this, several infrared receivers were interfaced through a standard CMOS logic gate to the microcontroller. The fourth is automatic video targeting, which is done with several algorithms inside the chip as well as an external camera: the C3088, which contains an OV6620 CMOS image sensor. The final PSSC is the ability to pan and tilt the turret assembly. To do this, several stepper motors are used, which are controlled using driver circuitry. The logic signals to this driver circuitry are sent from the microcontroller, although not before being translated into appropriate sequences for each driver using a GAL26V12 PLD.

The first few weeks of the project were spent determining the components to use and the specific desired functionality, in addition to prototyping an assembly for the turret and determining the necessary power to move the final assembly, to be made from aluminum. After this, the project moved to schematic, PCB and preliminary testing phase. At this time, the final schematic was completed after choosing the final components for every aspect of the project and the orders for building materials were sent out. Test software was also written for an older microcontroller to develop some basic control and receiver code for various modules. The next phase of the project

was the build, which took a few weeks both in the senior design lab and machine shop: to finish the circuitry and assembly, respectively. The final phase was debugging and testing, which was to continue until the project became fully functional.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project was the culmination of many things learned in earlier ECE courses. We used our knowledge of embedded system design from ECE 362 to successfully utilize and program our central microcontroller on our PCB. The motor driver on/off circuit from Lab 9 of that class was actually incorporated into the fire control circuitry for our project. Our knowledge retained from ECE 270 allowed us to successfully use glue logic and our PLD in various parts of the circuit, for instance the IR receivers for friendly detection and the motor control logic. Specifically for the PLD, we had to use our knowledge of designing sequential circuitry. For the IR receiver circuit, we used the knowledge of propagation time and non-idealities in logic gates to mitigate some noise on the receivers. Furthermore, some ECE 440 knowledge was used to identify where the receiver noise originated and why we could not simply use a filter to remove said noise. ECE 255 knowledge was used in designing our customized stepper motor driver, especially the fact that MOSFET gates are capacitive and therefore need pull-down resistors to drain off built-up charge that was causing malfunctions. Finally we used some knowledge of ECE 438 to come up with our video processing algorithm.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Among the things learned while doing this project were various electrical and mechanical design and debugging techniques.

We learned how to design a PCB from initial design constraints, to schematic, to PCB layout and finally debugging circuitry. In addition to this, we picked up a great deal of knowledge as to how to properly place and solder components on PCBs and breakout boards. We learned how motion sensors function, and design considerations that go into making a multi-regional motion detector from individual units. The IR receiver modules had the problem of receiving a great deal of in-band noise from ambient light. While we already knew about such noise from ECE 440 – Transmission of Information, we did not know how to deal with it. The solutions tried were both software- and hardware-based. There were things learned about video cameras as well, such as synchronization and modulation.

As for mechanical design, we learned a great deal about motor control. For instance, we found out that motor control software must allow the stepper motors to finish moving before sending the next step command. Related to this, the commands may not be sent too fast because the motors are unable to handle such RPM. We ran into issues when moving the main assembly too fast would cause too much stress on the bushing and led to instability. This was later fixed, although it was not something we initially knew how to deal with.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The objectives for this project were established before the semester even began. We wanted to design a sentry turret analogous to what may be seen in video games, or the Samsung sentry robot. We used these goals to come up with how we may actually reach these goals using an embedded system. Using this we came up with a basic design and then moved on to specifics. We determined

what subsystems would be required to achieve desired functionality: a serial communication interface, motor control, video processing and external memory. From these criteria, components were selected to best suit this. We picked a microcontroller that had the best available peripherals, expanded bus capability and speed; SRAM of sufficient size to store images; level translators where appropriate; sufficiently powerful transistors for driving circuitry; and a power supply that could source enough current to power everything. The assembly was built over a period of a month, and the PCB actually had to be slightly redesigned and rebuilt after the first iteration. In the end, we ended up with one almost functional and one fully functional (in terms of components) PCB that was used to test our software and control algorithms. We finally presented this to the class and staff to evaluate how well our design worked.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Obviously if this were to be supplied to military or law enforcement clients, then it would have to supply sufficient bang for their buck to justify spending money on an automated machine rather than training personnel for the same duty. Thus, it was a goal to try to keep the cost down while maintaining some reasonable functionality. Conversely, it was possible to think of this project as having to have minimal acceptable functionality, regardless of cost. Thus it could be marketed to the military as a method of defending indoor compounds or bases.

Environmental: There were only a few environmental concerns; however they are all relatively minor. The project assembly is constructed from aluminum, however there is nothing saying that the sheet metal may not be made from recycled materials. The components used are not RoHS-compliant; however this device is not intended to be simply thrown away. Finally, the device uses a significant amount of AC power; however it saves the need for using a more toxic, lead-acid battery as its power supply.

Ethical: One worry was that this device may be misused to illegally hunt animals. The solution to this was to implement an algorithm to determine if the target is human or not. It is also a worry that innocent bystanders may be harmed by this device. Again, it is recommended to the user not to use the device in a place where this is a risk. Furthermore, manual override and friendly detection shutdown exists for this very purpose.

Health & Safety: There are clear health and safety risks from this device, specifically personal injury from friendly fire or the device targeting a bystander who happened to be in the wrong place. This was dealt with in two parts. The purpose of the friendly remote shutoff is to allow friendly personnel to disable the turret without the risk of being fired upon. We would avoid shooting bystanders by instructing users not to deploy the device in areas where there may be innocent victims: for example, in any area where civilians or bystanders would not be allowed anyway, like a military compound.

Social: As with any defense-oriented device, there is the likelihood of protest by opponents of war and the use of deadly force. This was not taken into consideration for this project very much. One benefit to using an autonomous machine, however, is that it removes friendly troops from the line of fire. While this does not eliminate casualties of non-friendly personnel, it is a net reduction regardless. There may also be some protests of people losing work to automation. This is not taken into consideration at all, as it is no different than automating the manufacturing process. That is, those people can easily find new work.

Political: This is similar to social considerations. Again, we worried about this device being misused by governments for nefarious purposes, although this was no bigger a threat than any other

weapon. There is also a Luddite, technophobic part to society that could pressure politicians to ban robotic weaponry for fear that it would cause problems within the military or law enforcement, or that it could cause excessive dependence on automation for defense. We did not take this into consideration, as those fears are normally irrational.

Sustainability: The mechanical aspects of this project greatly raised the issue of sustainability. Since target tracking requires a stable platform for rotation and firing of the gun with out jerky motion, it was imperative that the design had to be made such that all the components on the packaging was will balanced and placed within the center. The design required precise autoCAD drawings as well as machinery that can cut the material to the closest mil. The decision to us a PC power supply as opposed to voltage regulators to supply the proper voltages to the components on the PCB was thought of because it would help support the weight of the motors on the gun assembly and the camera platform in the base of the packaging.

Manufacturability: With modern manufacturing technology, it should be fairly easy to mass-produce this device. The majority of the circuitry can be placed onto one PCB, which may be quickly and easily built by a machine. A CNC machine can cut and drill the necessary dimensions. The main question is: can everything be put together quickly and easily? This was not taken into consideration, however it was considered feasible during the design process that robotic arms could place, screw or weld together everything relating to the assembly. The cabling could be built easily, however humans will almost certainly be needed to make the final connections and to secure them.

(f) Description of the multidisciplinary nature of the project.

This project required the use of electrical, computer and mechanical engineering knowledge. The mechanical part is fairly obvious, as it takes mechanical skills to build an assembly such as the one seen in this project. It took a great deal of work to come up with a set of dimensions, materials and driving methods that would result in stable motion of the device.

The electrical engineering aspect dealt with designing workable IR receivers, motion sensors and motor driver circuitry. The knowledge gleaned specifically from ECE 438 and ECE 440 was used to design noise reduction systems and a video algorithm. Computer engineering was used to design the embedded system, glue logic and PLD for motor control logic.

(g) Description of project deliverables and their final status.

The project is contained in an aluminum assembly with two rotating platforms. The upper platform has the ability to both pan and tilt and holds the main weapon: an Uzi-shaped automatic Airsoft weapon. The lower platform can only be panned and holds the camera. The base of the assembly is a 12” by 12” by 8” high box, which contains all of the drivers, breakout boards, main PCB, power supply and cooling fans to help avoid overheating. The steel pipe that is the central rotation axis for the assembly is attached at the base of the box, and protrudes about 18” upward. A Matlab-based graphical user interface is available for controlling the turret manually via a standard serial cable.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	2
Project Title	Robert Johnson Bluetooth Mass Storage Device

Senior Design Students – Team Composition

Name	Major	Area(s) of Expertise Utilized in Project	Expected Graduation Date
Yuri Kubo	EE	Hardware Design	Dec 2008
Ryan Weaver	EE	System Integration	May 2008
Scott Pillow	CmpE	Software Development	May 2008
Yucel Parsak	CmpE	Software / User Interface	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Bluetooth mass storage device transfers data wirelessly using the OBEX (OBject EXchange) serial data transfer protocol over Bluetooth and also has future design plans to use a wired USB (Universal Serial Bus) connection. The user is able to initiate the data transfer over Bluetooth after 'pairing' to a host device, most likely a personal computer. A user configurable passkey is used for security purposes. Wireless data transfer is done utilizing a graphical user interface (GUI) that is unique to our device. This interface allows the user to browse the host PC, select files for transfer to and from the Bluetooth Mass Storage device, delete files from the Bluetooth Mass Storage device, and automatically display the updated file listing on the Bluetooth Mass Storage device. A low battery indicator LED lets the user know the status of the battery and will give the user 15 minutes to recharge the device. The USB connection facilitates the recharging of the battery while eventually giving the user continued access to their files. The motivation behind this project is based entirely on ease of use, convenience, and exponential growth of wireless connectivity. The user will most likely be anyone that uses multiple computers. The approach to this project was that of the engineering method and included various professional constraints.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project built upon a lot of previously learned knowledge and skills that were acquired in earlier ECE coursework. The previous coursework that was utilized the most was ECE 362: Microprocessor Systems and Interfacing. The embedded lab laid a foundation for the more technical problems faced in this project including timing diagrams, using datasheets, integrating with hardware, embedded software, troubleshooting, and using the logic analyzer. Other skills used from other classes include basic circuit analysis from ECE 201: Basic Linear Analysis, knowledge using discrete transistors from ECE 255: Introduction to Electronic Analysis and Design, basic knowledge from digital circuits from ECE 270: Introduction to Digital System Design, UART communication from ECE 337: ASIC Design Laboratory , advanced C language concepts including linked lists and arrays from

ECE 264: Advanced C Programming, and object oriented programming, Python language used in the GUI from ECE 364: Software Engineering Tools Laboratory.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

There was a vast amount of technical knowledge and skill acquired while doing this project. The largest amount of knowledge gained included printed circuit board (PCB) layout and the associated design considerations to reduce noise. The soldering techniques for populating a PCB with surface mount parts were also learned. There was also a lot learned from designing an embedded system from the ground up including component selection, interfacing major functional blocks together, and troubleshooting various problems. The technologies that were learned included Bluetooth, USB (Universal Serial Bus), UART (Universal Asynchronous Receiver Transmitter), and the implementation of the mass storage class for data storage. There was also a great amount of knowledge learned from designing a power supply with multiple voltage rails acquiring power from a rechargeable battery.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process was incorporated into the project throughout the task of designing the device. The Project Specific Success Criteria (PSSCs) were first determined based on a project idea. A block diagram was then created from these PSSCs. This allowed for component selection to make the various modules in the block diagram. Once the components were selected, a schematic was made interfacing all the major components together. Passive components were added as needed. Once the schematic was finalized, a PCB was made and sent to a manufacturer for fabrication. Once the manufactured PCB was returned, it was populated using surface mount parts. The board was then tested and evaluated. Then software was developed and placed onto the embedded system. This system was tested and updated numerous times to achieve the desired state of functionality. Once this functionality was achieved a package was constructed to hold our device in a user-friendly way.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: To keep the cost of the product down for the end user, price conscious parts were chosen when possible. To keep the cost of development down, samples were ordered when available.

Environmental: To remain environmental friendly, RoHS compliant parts were chosen when available. The power consumption of the device was kept as minimal as possible. A rechargeable battery was used to keep waste from the product to a minimum.

Ethical: Ethical constraints of the device included measures to keep the data secure through Bluetooth encryption and a passkey. The data is not corrupted during transfer, and the entire design process was well documented.

Health & Safety: Health and Safety constraints had to be implemented in the design of the device. A lithium ion battery was used which can be life threatening if charged improperly. The corners of the device are rounded to prevent injury. The device does not get warm to the touch to prevent the user from being burned.

Social: With the increase use of file sharing this device will eliminate the need of toting around a computer to distribute files. The user can be more social and is not tied to a specific computer nor slowed by connecting and disconnection the popular flash drive.

Political: With the growing use of technology in politics, having an easy to use device for portable file storage may allow politicians to quickly share ideas and files. This device can be used as a tool to improve political implementation.

Sustainability: A reliability analysis was done on the design to determine if our device can last an adequate amount of time without failure or repair.

Manufacturability: The device can be manufactured easily. All parts are available and a list of such parts has been made. The PCB can be easily manufactured from the files created with the PCB tool. The packaging can also be easily manufactured if designs were created for automated cutting tools.

(f) Description of the multidisciplinary nature of the project.

This project integrated many disciplines that were both engineering and non-engineering related. First, electrical engineering was highly utilized in the hardware design of our project. Secondly, software engineering was used to create all of the embedded software in order to add desired functions to the device. Environmental engineering was used in creating an environmentally conscious product. Non-engineering disciplines such as law and communication were used in discussing patent liability and creating all of the necessary documentation. Also, mechanical work was done in the fabrication of the packaging.

(g) Description of project deliverables and their final status.

The project deliverables include a fully functional Bluetooth Mass Storage device that is neatly packaged, an archived CD with all of the documentation created over the course of the semester, a final report describing various considerations and constraints used throughout the design process, and a poster showcasing our steps in completing the project.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	3
Project Title	BEARS

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Nikita Solilov	Comp. E	Firmware/Architecture	May 2008
Nick Stephens	EE	Communications/Hardware	May 2008
Jon Pendlum	EE	Communications/DSP	May 2008
Ryan Giltner	Comp. E	Software/Integration	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Bearing Emergency Alert Road System (BEARS) allows emergency vehicles to notify the nearby motorists of their emergency status. It displays direction and relative distance of EV to motorists using RF to communicate and GPS at each unit to calculate information. This product would be a two-way buy in that emergency vehicle branches must purchase the unit to support motorists' units. The motorist units would be either individually bought or included by car manufactures in their initial design.

The system is activated when the sirens of the emergency vehicle are turned on. The emergency vehicle is equipped with a GPS receiver to mark its location, and an RF transmitter to broadcast the vehicle type (fire, police, medical) and its present GPS location to surrounding vehicles. Individual motorists are equipped with a GPS receiver of their own as well as an RF receiver. The RF receiver will detect when an emergency vehicle broadcast is being made, and thus an emergency vehicle is in the area. A local microcontroller will calculate the distance and relative location of the emergency vehicle from their present vehicle location by comparing the transmitted and local GPS data. An LCD screen will then alert the motorist of an emergency vehicle's presence.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The BEARS project provided a great opportunity to apply knowledge and skills attained in our previous ECE undergraduate coursework. The circuitry and schematic design used basic knowledge learned in ECE 201, ECE 202, ECE 255, and the ECE 207/208 labs. Elements such as the power circuit design, diode and transistor selection, voltage dividers were used from these classes. Also, the digital systems course ECE 270 and microcontrollers course ECE 362 were used extensively, as BEARS is a microcontroller project, and a direct extension from the curriculum in these courses. In ECE 270, skills learned such as datasheet reading and digital parts selection were utilized, and from ECE 362 it was particularly useful having background knowledge of common microcontroller

peripherals such as SPI, SCI, and PWM. The software was coded in C, and much of the C experience came from courses such as ECE 264 and ECE 495 VIP. Finally, BEARS uses a radio frequency transceiver, and knowledge in using this component stemmed from ECE 440 for the communications theory and ECE 311 for the electromagnetics.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

During this class the skills of our team were stretched and improved. Technical selection of the components was one of the skills exercised extensively. Not only did we have to select the components based on the parameters we needed we had to find them cheaper or write letters to get the free donations. PCB design also proved to be an interesting endeavor that spawned many insights into the development of a live product. As a side note, we came to realize that PCB layout is an iterative process and a critical one (if done correctly you would not have to spend time fly wiring anything). Soldering of the components is yet another important skill. Soldering 0.5 pitch microcontroller to the PCB was a tricky feat, but also a satisfying one. Packaging, working with power tools (Dremel, saws, and pliers) was another great skill that we acquired. Finally, while this might not be a technical skill, technical communication and group activities, overall summarized by "groupware" was yet another skill that proved to be an essential part to project completion.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Our project started with generating ideas for an interesting project that will help others. We had brainstorming sessions in which we finally honed in on the BEARS project. As part of the project we defined success criteria to evaluate our efforts which then got translated into objectives that we divided amongst our team members. Each of the members was responsible to create an analysis for their respective objectives and figure out what is the best course of action (parts, resources, prototypes). The system architect (Nikita Solilov) then made an analysis of the overall system to ensure all of the parts will interact successfully and made final adjustments in the plan. Synthesis and construction took the longest amount of time to complete. Once all of the resources were allocated it was up to the individual team members to get their parts to work, however, we found that sometimes it is best to complete highly technical and challenging parts as a team. Following the construction we took our system for a test drive to ensure proper operation under myriad of conditions. We evaluated our success criterion by writing additional code to test each of the outcomes and tested it repeatedly to ensure the results were not simply flukes.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The purchasing of our devices could provide strain on the budget of many emergency vehicle branches, but they would be a rare purchase as the units can be transferred to new cars. The benefit that this system would provide far outweighs the costs. If the car manufacturers purchase this product, then the transmitters could be sold to the emergency vehicle branches at a low cost to promote use.

Environmental: Our printed circuit board and maximizing the battery life of the car are our two main environmental issues. By placing additional copper pours and making the device RoHS, we will minimize the amount of chemicals and lead used. To maximize the life of the car battery, we will implement code that turns off the LCD backlight when there is not an emergency vehicle around. This will substantially lower the amount of current draw to our system.

Ethical: Most ethical concerns of our device pertain to impairing the driver's ability in one form or another or false positives. In order to eliminate false positives from would-be hackers, the RF transceivers we use will be encoded. Steps to avoid impairing driving ability include warning labels in the documentation to raise the concern of the device taking away attention from the road.

Health & Safety: This system should prove to make the roads a safer place, especially for deaf motorists and users with loud sound systems. The only real safety issues are taking attention away from the road, but that is up to the motorist's initiative to heed our warnings in the user documentation.

Political: The devices could suffer some political strain as they need to be pushed through the emergency vehicle branches. We hope that each branch (fire, ambulance, police) would adopt the use of this product. To get this pushed through each of those branches separately could prove difficult.

Sustainability: Our product is very sustainable in that it can be transferred to and from different vehicles. This means that one household only really needs one or two receiver units. The product itself has a long lifespan (~100 years) and should be a rare purchase.

Manufacturability: Although there are slight differences between the transmitter and receiver, all of the differences are only in the code loaded onto the microcontroller. As such, they can be manufactured exactly the same but loaded with different data. This allows a cheaper method and better continuity.

(f) Description of the multidisciplinary nature of the project.

Our project involved different engineering perspectives and practices. BEARS has RF link and GPS unit which must interact without interference. Knowledge in communications was essential to getting that part of the project to work together. The unit is packaged and is intended to be used in a car, thus in mounting of the unit we had to take into considerations of the vibration, strain relief and flexibility of the PCB which is largely a field of mechanical engineering. Of course the firmware of the project was written by computer engineers, while the electrical component selection and circuit prototyping was done by the electrical engineers.

(g) Description of project deliverables and their final status.

In its final implementation, the BEARS system achieved all five of the defined project specific success criteria. These included the ability to display GPS information on the transmitter and receiver, notify motorists of transmitting vehicle's presence, generate and transmit emergency vehicle information, specify emergency vehicle type via touchscreen input, and to determine the relative distance and direction of a transmitting emergency vehicle. All of these were successfully demonstrated. However, there were a few additional features that had earlier been discussed and their capability is actually achievable with the current PCB, although software changes would be needed. A PWM driven small-speaker was planned to sound off when a transmitting vehicle was detected, but due to packaging constraints it was not included. Also, some software has been developed to display a street map image of the current location of the GPS receiver, but due to time shortage in finishing this feature, it was not included in the final version of BEARS.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	Team 4
Project Title	agatha

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Zach Dicklin	CompE	Software and Circuit Design	May 2008
Amy Ritter	CompE	Software Design	May 2008
Ian Bacon	CompE	Software and Project Management	May 2008
Eric Yee	EE	Hardware Design and Time Management	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

Agatha is a targeted advertisement solution designed to be located in public shopping areas typical of large commerce centers. This individualized approach to advertising will help to promote products to consumers who are more likely to be influenced by the selected promotion. Agatha works by collecting a database of previous shopper history, either through preloading on the SD card or through the tracking of user whereabouts through RFID tags. When a user approaches an Agatha kiosk that data is analyzed, and an appropriate advertisement is displayed. Agatha will most likely be purchased by large retail managers who are looking to create cross promotion between their outlets and are able to collect the information needed.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The design and construction of Agatha is a logical extension to the previous skills and knowledge previously attained throughout ECE. The selection of parts required extensive knowledge of integrated circuits and electronic and new knowledge of new design components was gained through reading datasheets and deciding on the final parts chosen. PCB design was an exercise in patience and time management that we had perfected previously in our ECE coursework as well as learning how to ensure correctness in a design that only had one opportunity to complete. Previous software design work had prepared us well for developing code to function on the development board and final design, but we gained new experience with different software tools and an abundance of new knowledge of specific hardware components including the Freescale NE64 microcontroller and a standard SD card. The ECE 362 mini project was an introduction to product design, but an in depth knowledge was gained toward the steps of designing a product: idea generation, product research, component selection, hardware and software design, and prototyping.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Hardware components were one of the biggest areas of knowledge gained throughout the project. Many different parts were looked at and many were considered for use in the final design. An understanding of many widely varying parts was obtained in order to complete this project. The SD card was a very unique challenge in that an entire interface had to be built and understood. SD cards use special commands and error codes to communicate over the SPI lines. PCB construction was a useful skill obtained during the project. Many hours were spent learning the intricacies of Orcad Layout and PCB construction in general. General guidelines to PCB layouts were learned as well as steps to take when starting a PCB from the beginning.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process was incorporated throughout the entire project. We first started the project by deciding upon an idea that we were able to do within the length of one semester. Our objectives were created within the first couple weeks of the class so that we could actively see our project through to completion. Next, components were chosen that would synthesize to bring the project together and obtain our goals. Several modifications to the code making use of the components were tested to understand how each one works and how they can all communicate together. Through each step in the project, analysis was done to ensure that we were leading to the final goal to pass all of the objectives that were created. The construction of the kiosk helped place our components inside the box and view the overall design. This led to several evaluations from us that altered our code to make it even better.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The Agatha kiosk is intended for advertising a market already saturated with numerous tools, so a variety of economic constraints were considered. Ideally, the project should be less expensive than other advertising options with similar or greater impact. It should be cheaper and require less maintenance and energy than a low cost computer system that could accomplish a number of the same tasks without also limiting effectiveness.

Environmental: Agatha is fairly standard when it comes to environmental issues. It does not have any stand out parts when compared to most consumer electronics, but being like any standard electronic it does have some features that are a concern to the environment. Each of Agatha's stages of life, production, normal use, and disposal all have different specific concerns.

Ethical: Agatha has very few features that can be deemed physically dangerous. Most of the ethical issues with Agatha are based around privacy issues. Information about the previous shopping history of users is collected and stored on the device. Personal advertisements are also displayed in a public environment. It could be possible for a malicious individual to gain information about the targeted users. This information, however, can not be linked directly to an individual.

Health & Safety: Agatha is not intended to change the health or safety of any individuals involved. Agatha is not intended to physically interact with any users. There is some small possibility that the actual kiosk can fall and potentially harm a user if not properly weighted down.

Sustainability: The Agatha kiosk will likely operate in a setting with a number of identical, networked kiosks and RFID readers. As such, the kiosk was designed to require little maintenance. Parts with high sensitivity or shorter lifespan should be easy to repair or replace. A complete Agatha network is likely an expensive advertising tool, so the device should last a number of years without nuisance.

Manufacturability: The Agatha kiosk is very simple to manufacture. It consists of a very simple outer box that can be produced very quickly. The electronics consists of a PCB interfaced with an SD card and a Reach SLCD. All of these things are simply built and could easily be connected together by the end user as shown in the User Manual.

(f) Description of the multidisciplinary nature of the project.

The Agatha project involved many different areas of work. The hardware component selection was much focused on the electrical specifications and the compatibility of different types of circuits. Also the power system for our project needed to supply appropriate levels to the various circuits. These components are a part of Electrical Engineering. The abilities of a Computer Engineering were highly valuable in the production of selection algorithms, software interfaces of components, and the creation of the capabilities the design would need. Software Engineering tools were useful in software production focusing on maintaining the appropriate size of code as well as the final functionality of the developed product. Others disciplinary skills such as technical writing were useful in order to express the capabilities of the project and to outline the various features of Agatha throughout the various reports.

(g) Description of project deliverables and their final status.

The Agatha kiosk performs all of the functions outlined by the Project Specific Criteria. After reading RFID tags located in shopping bags from an external antenna, it retrieves shopper preferences from a database stored on an SD card, runs an algorithm to determine the best matching advertisement, and displays it to the screen. When tags are not available or detected, the kiosk continues to serve as an advertising tool by rotating through its advertisement database. All of these features operate successfully.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	5
Project Title	SousChef

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Summer Mousa	CmpE	Client/SD Controller	May 2008
Peter Goreham	CmpE	Text-to-Speech	May 2008
Adam Schafer	CmpE	LCD Display/ Design	May 2008
Crystal Langenbrunner	EE	Speech Recognition	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The SousChef is a digital cookbook that recognizes voice commands and reads recipes aloud to the user. Recipes are stored on an external flash memory drive and recipes are written and updated by PC client software. The idea behind the SousChef is to provide customers a hands-free approach to cooking, where users have one-stop easy access to all of their favorite recipes and they do not have to worry about spilling ingredients and making the recipe steps illegible.

The approach behind developing the SousChef is that it initially polls the user for a spoken command. Once the command is heard, the microphone is disabled and the SousChef performs the command. If the command is to read a recipe, then another command will not be detected by the SousChef until the reading portion is complete. Also, the user can set their own recipe timers through the use of client software. When the SousChef encounters a timer, it prompts the user on whether or not they choose to set a cooking timer.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

A lot of the SousChef's design is based upon many of the concepts learned in ECE 270. To build the schematic required knowledge of OrCad Capture. Reading and understanding datasheets, as well as knowledge of programming PLDs is acquired from the aforementioned digital logic course.

Another important course is ECE 362. ECE 362 gave us knowledge on how a microcontroller works and its different modules. The type of modules that we used was the SPI and the Timer. We used our knowledge of interrupts as well.

To understand UART protocol required knowledge from ECE 337. Basic circuit design originated from ECE 201 and ECE 202. Finally, files system structure was learned from ECE 469.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Before senior design, PCB design was not something taught in ECE courses. Through multiple revisions of the PCB, instructions from the senior design staff and hindsight, effective PCB design is a skill that was developed by team 5. While knowledge gained through past experiences was useful, the most helpful resources were the data sheets for the components we selected. Reading and understanding datasheets is a skill that was developed throughout the duration of this project. Solutions for challenges faced were often found in the datasheets and required reading passages multiple times. Technical writing was a skill use often during this project. Past courses did not provide such extensive technical writing requirements. Production of the test circuits and the PCB required mastering soldering. Creation of the development boards was done by soldering the PIC to breakout boards. The PCB required soldering many packages and wires to it.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Speech recognition was a project idea that was appealing because of Crystal's experience and our team's interest in it. Recognizing the projects central theme of speech recognition the remaining modules were designed around it. The projects premise required data storage so a SD card was chosen. Text to speech was selected to provide a more enjoyable user interaction. Testing of the SousChef began with the test circuits for each individual module, modules were divided among members of the team. Once a module was working effort was reallocated to the remaining modules. Once testing was completed, construction began by populating the PCB. The project was evaluated according to the PSSCs.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: All components were chosen to be as cheap as possible. Of the components with a notable cost, the microcontroller is $6.20 per unit, the SpeechJet chip is $12 per unit, the LCD is $15 per unit, and a mass-produced version of the PCB would add little to that cost. In the end, the product should have a MSRP less than $100, which is hardly expensive for such a product.

Environmental: All components are lead-free, lead-free solder was used, and the unit's power consumption is low. Plans were made to give consumers a way to recycle the product as opposed to throwing it away, and the PCB would be made much smaller for the commercial application.

Ethical: Care will be taken to properly warn the user against improper use, and sufficient product testing will be performed to check for critical errors in hardware/software.

Health & Safety: See Ethical

Social: Not Applicable

Political: Not Applicable

Sustainability: Along with sufficient product testing prior to sale, care was taken to choose a package that should hold up under regular use. The product should be able to survive a fall from counter-height, and none of the components used should have a noticeably short lifetime.

Manufacturability: The most difficult part of the manufacturing process would be modifying the packaging to fit the LCD screen and speaker. Other than that, it is simply soldering components onto a PCB – large amounts of off-chip wiring are not necessary.

(f) Description of the multidisciplinary nature of the project.

There were only a few disciplines that contributed to the SousChef. Computer engineering was needed to complete the coding that was required for the whole project. Electrical engineering was required for designing the schematic, the PCB, and working with the different physical components of the project.

(g) Description of project deliverables and their final status.

The project is currently not entirely finished. The LCD, timer, and text-to-speech module are all working together. The SD card and the voice recognition are in the process of being finished, with the voice recognition working except for the microphone.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	6
Project Title	The Touch

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Ross Beranek	CompE	Design/Programming	May 2008
Chris Hacker	CompE	Embedded Programming	May 2008
Rajat Agarwal	CompE	Programming	May 2008
Doug Dicio	EE	Circuit Theory	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Touch is a digital board game with a touch screen interface. This device was created to make playing board games easier for the user. This device eliminates the need for picking up messy pieces or manually keeping score on certain games. The Touch utilizes an LCD screen with a touch overlay to allow the user to see and move pieces with the ease of a touch. The user can select an option or piece they would like to manipulate and then select what that option becomes or where the piece moves. The Touch also utilizes Secure Digital cards to allow the device to have multiple possible games located on these cards.

Since this is a portable device, the power circuit was created with recharging capability specifically for this product. The estimated life time of one charge is around 5 hours which gives the user plenty of time to play their games. The entire project is built around the Freescale MC9S12XA512 microcontroller which provides us with adequate interfaces to each of our devices. The stages that occurred during our creation of The Touch was the design phase which took a lot of research to determine what each of our components should be to allow them to work together properly. We then designed a printed circuit board by first creating a schematic and then placing and routing a circuit board. After this software was written to work on our microcontroller and was uploaded successfully to our microcontroller after much testing and debugging.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project built upon almost everything that we learned in earlier ECE coursework. As for the circuitry, it took a lot of our knowledge from EE related courses such as ECE255 and ECE201. Knowing which passive components to use in order to create a working circuit board was crucial to this project. Other courses such as ECE270 and ECE362 were helpful when it came to working with microcontroller circuits and their peripherals. Because of these courses, additional research into microcontroller interfaces such as SCI and SPI was not needed. As for the programming of the microcontroller itself, it was felt that a lot of the CompE classes were extremely helpful. Knowing C

programming and certain data structures and string manipulation it made programming our microcontroller all that much easier. All in all the earlier ECE coursework provided us with all of the necessary knowledge and experience needed to create a fully functional project.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Some additional technical skills were acquired during this project. We had never worked with oscillator circuits before, so when we needed to create our circuit to run at 25 MHz much learning was involved as to how that circuit should be created. None of us had ever created a PCB before either, so creating a functional printed circuit board was a new skill that we acquired, and were very happy to do so. We also learned how to use CodeWarrior, which is an extremely helpful skill that will be needed when working after graduation, because real time embedded software tools are a good thing to know.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Before the semester started, our group brainstormed ideas for a project that we thought would be fun, and also would be doable based on a lot of our knowledge. We then decided that a touch interface should be used and SD cards should be utilized. From this information we made our PSSCs to gauge our progress. Once we decided to create The Touch, we researched components that would be useful in the creation of the device. Once we knew which components we wanted to use, we created a schematic connecting each of these devices with our microcontroller. After this schematic was satisfactory, we created a printed circuit board file by placing and routing our components and traces, and then sent it in for fabrication. When we received our board we then tested it and connected our devices so that it may be programmed. During this entire process, coding was in progress. We first started out by creating flow charts for our programs and then decided which functions we would need to write and drew a hierarchy of these functions. Once we decided on an appropriate flow to our program, we then started the programming process on our development kit. Debugging and testing of the program was done on both the development board and our printed circuit board. Evaluation was based on our PSSCs that we came up with during the brainstorming process.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: In designing The Touch we realized that the product would need to be marketable to the public, and because of this would need to be inexpensive. More importantly was probably the fact that we were designing this on the budgets of four college students and could not afford to waste a lot of money.

Environmental: Knowing that our project would contain products that could harm the environment, we wanted to insure that these would be minimized. This is why we used ROHS compliant materials whenever we could, and used a NiMH battery.

Ethical: Since we know that many of the users of The Touch will be children, we did not want to use a game that would be violent, or for mature audiences. This is part of the reason for why we choose to use a classic game like Checkers.

Health & Safety: Since we were designing a product that would be used by the public, safety was a top concern. In doing a safety analysis we identified the critical components that could fail and how

they would affect the system if they did. Since The Touch has a battery, we insured that the probability of the battery becoming overcharged was extremely low.

Sustainability: Since we wanted our product to perform well for a long period of time we tired using products that were not prone to failure. This included avoiding products that have just come out, and may not have all the kinks worked out yet. Also the this influenced our packaging decisions greatly, and was why we used a strong, durable plastic case.

Manufacturability: In designing The Touch we tried to minimize the number of components used because any wasted materials would add to the cost and time of manufacturing the device.

(f) Description of the multidisciplinary nature of the project.

The Touch was designed by Computer and Electrical Engineers, and mainly was influenced by these disciplines, but it also benefited from proficiencies from other disciplines. The idea itself would be influenced by marketing and sales positions to insure that it would be desirable by the public. The design of it would be benefited by artists and designers who could make it aesthetically pleasing. Management and leadership were present in the design process, because in every aspect we were working with a team trying to reach this common goal. Business skills were necessary in dealing with the other companies whose products we used in the making of The Touch.

(g) Description of project deliverables.

The Touch has successfully met three out of the five project specific success criteria. The criteria were demonstrated to the course staff and a video was made showing the success criteria being met. A final report which outlines the design decisions made and rational has been submitted. The projects website, which includes all submissions and presentations has been archived on a CD and submitted.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	7
Project Title	Electronic Cornhole

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Andrew Reder	Electrical	Hardware	May 2008
Jimmy Tsao	Electrical	Hardware	May 2008
Ryan Scheckelhoff	Electrical	Team Leader, Software	May 2008
Tom Collopy	Computer	Software	May 2009

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The idea of working on an electronic cornhole game was born from many hours of playing cornhole in college and seeing the need for an easier way to keep score. Often times, with varying rules being played and distractions abounding during play, the actual score can become a source of confusion or even controversy. Our idea was to create a prototype of an automatic scoring, electronic version of the game, with a large digital display showing the score, game status, and other pertinent information. We had heard that RFID technology could be used to identify a specific, discrete transponder tag within a certain range of an antenna. We felt that with the low cost of RFID transponder tags, a digital display screen, and the increasing use of RFID modules making their use less expensive, we could deliver a prototype of one cornhole box for a price less than $500, which if translated into a consumer product could be made much lower ($200-$300) in mass production quantities. Since high quality standard cornhole sets can sell for well over $100, this product could be very competitive in the recreational equipment market.

For our proof-of-concept project, we decided that building one functional cornhole box (even though the game is played with two, one on each side) would serve as a meaningful demonstration that such a product could be designed. We focused on the major functionality that such a system would need to have in determining our Project Specific Success Criteria. These criteria included being able to distinguish tags as being on top of the cornhole box and inside the hole of the box, being able to tell the difference between bags belonging to different teams, being able to display the game status, and being able to control the whole system with a versatile remote control. The remote control aspect of the project was a late addition intended to promote usability of such a product, and since a normal infrared remote control would be unreliable in the outdoor, sunny environment that cornhole is normally played in, we decided to use Bluetooth radio frequency, which is adaptable to many current consumer devices, including cell phones and PDAs. The RFID approach was to select two different reader and antenna systems that would be able to identify tags on top of the board and inside the hole of the board separately, using metallic shielding to prevent overlapping fields if necessary. Two custom antenna designs were implemented with the restriction of both read zones considered separately, and a low cost reader which could read multiple tags simultaneously was selected for both zones.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Since this senior design course is the natural successor to ECE 270 and 362, obviously much of the emphasis in this course is on advancing the techniques learned in those aforementioned courses. Selecting a specific microcontroller with appropriate peripherals, speed, and memory for use in the project was a way to further enhance the analysis of microcontrollers learned in ECE 362. Furthermore, learning how to actually lay out a printed circuit board with the components necessary to support the interfacing of the chosen microcontroller to the devices used in the operation of the design project was a hands-on way to apply the principles learned in ECE 362 and ECE 270 to this project. The circuit analysis techniques learned in ECE 201 and 202 along with their associated laboratories were of great use in debugging and making common sense decisions about the PCB layout and operation. The RFID system analysis required a basic knowledge of electromagnetic fields and antenna design that were touched on during ECE 311. Experience in reading datasheets and analyzing amplifier circuitry was greatly useful in analyzing and implementing the amplifier design for the larger, top RFID antenna. Finally, the coding in Code Warrior was implemented with the help of the C programming techniques learned in ECE 264.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Obviously there were various lessons learned and new skills acquired in the implementation of this project that reached outside of the previous knowledge from ECE coursework. The most prevalent of these situations came from the PCB design and layout. Although previous courses allowed the opportunity to work with circuit analysis and design, and even building prototype circuits on breadboards and prototyping board, a custom PCB was a completely new and daunting challenge. The first part of this challenge was in fully learning the Orcad Layout software, something one team member had some experience with (but unfortunately not in the same software version or methods). Learning how to identify and create package footprints, utilize copper pours for EMI mitigation, and figuring out how to space everything intelligently were all new skills that were learned in this project. Furthermore, once the physical PCB was available to the team, lessons were learned in terms of effective soldering techniques, fly-wiring when necessary, and careful part orientation consideration. Learning how to read the important parts of datasheets and understanding the meaning behind them was also something that taught the team a great deal about the design process. At one point it was realized that the microcontroller being used was not the same one that had been referred to in the datasheet, but rather a derivative with fewer feature. Perhaps the most important experience from the project, however, was gaining confidence and insight into an efficient design process as a whole. Some issues that seemed important early in the project wound up being incidental later on. Other important considerations were ignored from the offset until they presented a complete roadblock to advancement later on. All in all, a complete design experience was gained that will yield confidence and wisdom for the future.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Once the Electronic Cornhole board was decided upon, the project was discussed in further detail to determine various methods that would be used to achieve full functionality. With these methods in mind, the block diagram was then drawn of the theoretical system. This block diagram was used to determine the five main PSSC objectives for the team. By taking this approach, the objectives were more modular and less dependent on one another, giving higher probability for successful synthesis of the project at completion. The PCB was then laid out based on the requirements of the peripherals chosen. Once complete, the power supply was constructed first, verifying that there was a safe

environment for the microcontroller to be soldered on. Once these were in place and tested, a heartbeat program was installed to verify a correctly working circuit. The level translators were then separately placed and tested for each SCI port requiring translation. Once the circuit was operational the peripherals were then separately tested. The large and small antennas were tested using a demonstration board and then transferred over to the complete system and tested one by one. The Bluetooth was implemented and tested last, as it was not needed for complete functionality because it was substituted by a pushbutton during testing. With the complete system working in sync, the objectives were evaluated and five out of five were successfully accomplished.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The economic constraints were motivated by the team paying for the project out of its own pockets. The team ended up spending almost exactly $500 on the project. More money could have been saved by buying parts that were less documented or used different interfaces, but that would have added considerable extra difficulty.

Environmental: The project used all lead-free components except for the PCB and the solder. Since this project is only a prototype, this is not a big problem, since modifications could be made if the project were ever to be mass produced.

Ethical: The lack of authentication methods on the game could open the game up to cheating, so with more time, adding security would be a priority. In any case, no personal information is stored, so the problem cannot extend outside of the game (i.e. hacking the device with its current capabilities would not pose a real security risk).

Health & Safety: While this project does not promote unethical behavior, one cannot deny that often too many alcoholic drinks are consumed during a game of cornhole. If people are going to drink there's no way to force them to stop, but a few well placed reminders to be careful can certainly help.

Social: Scoring a game of cornhole can cause arguments and confusion. With this project, the number of arguments should decrease and time spent worrying about the score can be spent socializing. Hopefully with this project, one can have a nice game of cornhole with his or her friends.

Political: This project did not have any major political design considerations.

Sustainability: Physically, our project is made up of several modules, and if one breaks, it can be replaced. On the other hand, the RFID readers used were becoming obsolete and are not in production anymore. A future revision of the project could be written to incorporate newer RFID readers, but these readers were much more user-friendly and made the prototype much easier to build.

Manufacturability: Our project could not be mass produced in its present design, because the RFID readers we used are not available in a large quantity. Also, the LED display was nice, but very expensive; we would probably design our own LED display if we were to mass produce the project. In the prototyping stage, there was some uncertainty about how the team was going to get the project to work, and so it was desirable to use very well documented parts. Upgrading the project would allow the design to be more experimental, and upgrading would be necessary before we could manufacture the project.

(f) Description of the multidisciplinary nature of the project.

This project required a variety of skill sets within the electrical engineering discipline. Working with RFID required specific knowledge of how to not only build, but tune high frequency antennas. The digital skill set was also vital in the layout of the hardware and software development. Along with electrical engineering skill sets, some mechanical intuition was required in constructing the project package. In addition to this, technical writing skills, project management, and communication were also a must in making the project a success.

(g) Description of project deliverables and their final status.

The project is all contained in a cornhole set and 8 bags, 4 for each team. An additional Bluetooth remote is required to obtain remote functionality; this can be done with a computer, a cell phone, or a PDA. Both antennae and the LED display are included in the board assembly. All five of the aforementioned Project Specific Success Criteria were successfully demonstrated.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	8
Project Title	OMAR

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Michael Cianciarulo	CompE		December 2008
Trent Nelson	CompE		May 2008
Josh Wildey	EE		May 2008
Robert Toepfer	CompE		December 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

OMAR is part of a solution to the Purdue IEEE Aerial Robotics' project which is an ongoing project and competes in the annual International Aerial Robotic Competition (IARC). Its primary function is to provide autonomous reconnaissance within an unexplored room. It is going to be land based wheel driven vehicle which will use an array of range finders and proximity sensors to autonomously navigate and map out a room while avoiding obstacles. In addition to that it will also have a camera attached which will take still images. OMAR will continue to navigate this room until a specified logo is identified and relayed wirelessly back to a base station, in this case, a laptop computer. OMAR has been able to achieve autonomous navigation and logo detection but was unable to complete room mapping. Regardless of the results it is still fully capable of completing the intended mission.

The project started out at the design level. Research was done to find available range finders, and embedded computers that could handle a lot of computation. After components were picked out, a block diagram was developed to give an overview of the components and interfaces. The block diagram was then turned into a schematic showing all the connections between components. The schematic was then used to make the PCB.

When the PCB came in, construction and testing started for the frame, PCB, and sensors. Around this time, the software model was developed for the micro-controller and embedded computer. Programming started for both, which also involved testing with the actually hardware. As separate functions of the design were completed, they were put together for more testing and this was done until the project was completed.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Some of the most important knowledge and skills to complete this project came from ECE 362. That class focused on using interfaces to connect external devices to the micro-controller and writing code to utilize those devices through the micro-controller.

The next major part of this project utilized knowledge from ECE 462, 368, and 264. These classes taught data structures, object-oriented, and basic programming which were needed for the embedded computer, as well as the microcontroller.

Lastly, ECE 201, 202 gave knowledge about discrete components and design for power systems. These classes also help us when we were designing our low pass filters for noise cancellation.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Throughout this project, we gained the knowledge necessary to design a working PCB. We were required to read documentation on how to design a PCB while reducing EMI. Not only did we have to learn the design aspect, we had to learn the how to use the Orcad Layout software.

In order to get all of the sensors working, we had to gain an understanding of the I2C protocol. Even with that knowledge, each sensor worked differently with I2C and we gained the technical knowledge to incorporate these sensors into any design (as well as any basic I2C device). We also learned the basic's of PID control loops. We learned how changing the basic gains affect the output.

Our project required real time processing, so we acquired the skills necessary to develop software for real time constraints. We also had to learn to keep the software within the scope of the embedded environment. In order to keep all code safe throughout the project, we used subversion. We had to learn the commands needed to utilize it as well as keep the repository working properly and well documented.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process helped organize the project to completion and provided vital steps in getting the project done. The first step was establishing the project goals. Our goals were already laid out for us since this project is a part of Purdue IEEE's aerial robotic competition. From these goals we came up with the success criteria for what we wanted to accomplish during this project. The next step was to analyze the criteria and figure out how the project would actually complete its goals. From this, a block diagram of all the components required in order to meet the goals was made. From the block diagram, we synthesized the project into a schematic which demonstrated all the connections between all the components. The schematic was then turned into a PCB design which showed all the connections traced out between components.

The construction phase started with the initial frame and motors. Once the PCB came in, it was populated right away and added to the frame along with the sonar sensors. At this point testing was done with the vehicle moving while avoiding obstacles. At the same time, testing started with the embedded computer, camera, and wireless communication. This didn't need the vehicle in order to operate, so testing was separate from the vehicle. Near the end of construction and testing of each part, the camera and embedded CPU were connected and tested all together with the vehicle.
The end of the project brought the last step, evaluation. The project was evaluated based on the goals and criteria set forward from the beginning. All the goals were met except for mapping the room.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of <u>most</u> of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: This project was funded by Purdue IEEE. Our project is not meant for mass production since it is just for the competition. In light of this, we didn't worry about the cost of components.

Environmental: This product is intended to move around in the environment and needs to be to be able to handle a different range of environments. This factor led us to make sure that the motors could drive the vehicle with enough force for flat, hilly, bumpy surfaces.

Ethical: One of the reasons this project won't be mass produced because people may use this product for unethical reasons.

Health & Safety: We added the ability to start and stop the vehicle via wireless communication so that OMAR can be stopped if safety is a threat. No parts involved in this project provide any kind of health threat.

Social: OMAR was designed and named in a fashion that it will not be offensive to anyone or any group. We have limited its speed so that it will not interfere with potential innocent bystanders. In addition, it uses object avoidance so that it should not conflict with bystanders.

Political: OMAR was designed for military and/or law enforcement applications. Even though this is strictly stated in our user manual, it is extremely difficult to enforce these guidelines. If OMAR were to be used unlawfully, it could cause major political conflict whether or not it falls into the wrong hands.

Sustainability: Since this project only needs to work during the competition for 20 min, a battery is used to power the vehicle. There was no need for a recharging unit or power display.

Manufacturability: Since this product was not intended for mass production. With out any constraints, the packaging of the vehicle didn't have to be done in a way to easy manufacture this product.

(f) Description of the multidisciplinary nature of the project.

The two major disciplines needed to complete this project were Electrical Engineering and Computer Engineering. Knowledge and skills ranged from programming on a computer and micro-controller to circuit design. Throughout the course, technical writing skills were used to write the many papers and presentations describing the project. Also, communication skills were needed for giving the presentations throughout the course.

(g) Description of project deliverables and their final status.

The project is delivered in one small package. The inside of the structure holds the PCB, motor controller, motors, and embedded computer. The motors were wrapped with a magnetic shielding to reduce interference with the PCB. The top of the structure holds 5 sonars connected to the PCB, a camera connected to the embedded computer, and the battery which runs to the PCB. The structure is held up with four foam tires. It also has a spoon pointed out at the end to prevent it from flipping over, and a ramrod pointed out the front end to prevent the vehicle from hitting walls and damaging the sonars.

All the PSSC's were completed except for one. The mapping of a room was not completed and is not available in the delivered project. To get the project working, one has to plug in the battery and wait for the wireless to get connected. The vehicle doesn't start moving until you send a go command from a computer to the vehicle. Once it starts, it moves around the room avoiding obstacles by using the sonar. While is moves, the camera takes pictures. In order to get the pictures, they have to be copied over to a computer.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	9
Project Title	myRoom

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Zach Beechler	EE	Hardware Development	May 2008
Laurie Duncan	CmpE	Software Development	May 2008
Andrew Hampton	CmpE	Software Development	May 2008
Gesine Hinterwalder	EE	Hardware Development	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

myRoom is a complete, customizable room control system. It is meant to be mounted near the entrance to a room. Each family member will have an ID card with built-in RFID technology, which is scanned upon entering the room. When myRoom detects that a new person has entered, their personal preferences - which have been input by the user via an Ethernet connection – are accessed by the microcontroller. Appliances that are controlled by myRoom (which include light, TV, DVD player, CD player, etc.) will be changed instantaneously by receiving infrared signals sent by the myRoom system.

myRoom was created to be an innovative system that would entice customers by being both fun and functional, as well as being a good way to conserve energy. The purpose of myRoom is to make the use of regularly used home appliances easier and less tedious. When users don't have to shuffle through numerous remote controls to turn on and adjust their electronics every time they enter a room, they are able to get more use and enjoyment out of them. myRoom's ability to turn off all appliances when the user leaves the room adds the benefit of energy conservation for those who might forget to turn off their appliances otherwise.

The myRoom idea was the end product of many weeks of creative brainstorming. Team 9 wanted to create something new and novel, which would be challenging yet feasible to develop. The original idea, which came from Andrew Hampton, was to create a system which would recognize a user by RFID when he or she entered a room, and change the room's ambient electronics to his or her settings via IR transmitters. Since this was our most interesting yet feasible idea, we decided to go for it. The next step was to decide which electronics to interface the myRoom system with. Originally, we wanted to use low key room enhancers, such as wall-washing LEDs, a digital photo frame, and a CD player. The primary limitation we encountered in this phase was finding electronics that either we already owned, or would be affordable given our limited funding. In the end, we settled on interfacing with a TV, a DVD player, a CD player, and a light and a fan using X10 technology.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This course was the culmination of years of ECE coursework for the members of Team 9. It was in many ways similar to the final project portion of Microprocessor Systems and Interfacing (ECE 362). Once again, we were expected to come up with a creative use for a microprocessor, add peripherals to it, draw it together with software, and do it all as part of a 4-person team. ECE 477 expanded on these skills, though, by making the project last an entire semester, heightening expectations, and allowing more freedom in microprocessor and peripheral selection and implementation.

Each phase of project development drew upon fundamental knowledge learned in 200-level courses. Designing the schematic and PCB required the use of skills from Linear Circuit Analysis I and II (ECE 201 and 202) and Introduction to Electronic Analysis and Design (ECE 255). Putting the hardware pieces together and testing it built upon knowledge from Electronic Measurement Techniques (ECE 207) and Electronic Devices and Design Laboratory (ECE 208). Designing, developing, and debugging the software portion of this project built upon skills learned in Advanced C Programming (ECE 264).

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

All members of Team 9 gained new technical knowledge and skills while working on the myRoom system. Gesine and Zach became more proficient at using Capture CIS to design schematics. They also learned how to use Layout Plus for the creation of PCB designs. Andrew and Laurie got to work with Freescale's CodeWarrior software for the first time, and improved their C programming skills. They also became more familiar with web development and CGI scripting. All four members of the team became more proficient at reading and understanding component data sheets, and gained circuit building skills.

All members also had the opportunity to practice soldering, desoldering, and circuit debugging.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The engineering design process guided Team 9 throughout the development of the myRoom system. We began by establishing objectives and criteria in the form of PSSCs (homework 2). These criteria reflected the primary goals of our project, and have guided our work prioritization throughout the semester. The analysis portion of the process was accomplished when we were preparing to design our schematic. We had to analyze component datasheets to find the peripheral components that fit best with our criteria and with each other. The project was synthesized into a single cohesive design through the Packaging Specifications, Hardware Design and PCB Layout Narratives, and the Software Design Narrative (homeworks 4, 5, 6, and 11).

Once the design was ready, the team began the construction and testing phases of the process. These two phases occurred simultaneously because the pieces of the hardware and software were both assembled modularly, and each module was tested as it was created. Finally, as the myRoom system achieved each of its five main criteria, it was evaluated by a TA who confirmed that the goal had indeed been reached.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: This was the primary constraint in the design of our project. Since the project was purely for educational purposes and was not supported by any corporate sponsors, all materials had to be purchased by the design team themselves. This limitation prevented us from interfacing with more costly home appliances, and gave us few options for expensive components such as RFID readers. However, this constraint did not prevent us from keeping with the original objectives of the project.

Environmental: Since the myRoom system is used to control home appliances, it has the potential to increase a user's use of electricity in the home. To prevent this detriment to the environment, and potentially even reverse it, we decided to add a shutoff feature which automatically turns off all active appliances when a user scans their RFID card on the way out of the room.

Ethical: The myRoom system needed to be ethical both in avoiding patent infringement and respecting others' intellectual property. A detailed analysis of potential patent infringements was performed, and we concluded that we were at very low risk for patent infringement. We also formed a plan of action in case of legal action being taken against the myRoom system.

Health & Safety: Ensuring that the myRoom system did not put users at health or safety risk was of course a top priority.

Sustainability: To ensure sustainability, we chose components from high-quality manufacturers and reliable vendors. This constraint helped us to be sure that the components within the system would not degrade for at least two years from first use.

Manufacturability: myRoom needed to be easily manufactured in a way that made it profitable while still meeting all other design constraints. By using a simple plastic casing which was only slightly modified to fit our packaging requirements.

(f) Description of the multidisciplinary nature of the project.

This project required proficiency in many disciplines for its completion. Electrical Engineering knowledge of circuit design and assembly was needed for the schematic design and PCB circuit assembly. Computer Engineering software development skills were needed to understand how the low-level code was interacting with the microprocessor, and to design and develop this code. Some knowledge of Mechanical Engineering was needed to make the project box accommodate LEDs and a push button, as well as make it wall-mountable. This project also required understanding of less technical disciplines, such as teamwork and leadership, ethics, and marketing.

(g) Description of project deliverables and their final status.

The myRoom system is currently able to scan RFID cards, and identify a unique user with it. When the card is scanned, the myRoom system retrieves the user's preferences, and transmits IR signals based on them. The myRoom system also has a learning mode, which allows it to receive IR transmissions from a remote control, and store the IR codes in memory. The one deliverable that was not accomplished was the ability to get user preferences from a website hosted on the microcontroller. The code for this deliverable was written and tested on the development board, but there was not enough time to integrate this code with the rest of the project code.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	10
Project Title	Global Pigeon

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
David Collins	CmpE	Software	May 2008
Matt Ligocki	CmpE	PCB Design	May 2008
Daniel Bixby	CmpE	Electric Motors	May 2008
Paul Ng	EE	Circuit Design	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Global Pigeon is an RC plane based Unmanned Aerial Vehicle capable of autonomous flight and navigation by GPS waypoints. The plane also features an onboard camera which has the capability to take pictures at specific waypoints during flight. The intended markets for the product are enthusiasts and commercial applications such as land surveying or aerial photography. The purpose of the product is to be able to remotely send a plane to a predefined geographic location and take pictures of that specific location.

The plane will consist of a commercially available RC plane, a custom made PCB, a GPS module, a microSD card, a camera module and a thermopile tilt sensor setup. The plane will utilize the GPS to identify its location. Also it will acquire the GPS waypoints on the microSD card. Using the thermopile tilt sensors, the plane will be able to navigate and balance itself during flight. Upon reaching the required waypoint, the plane will trigger the camera module to trigger the shutter of the camera. Everything is interfaced with a Freescale microcontroller. The takeoff of the plane is done manually using a traditional radio controller setup. Upon reaching the desired altitude, the control of the plane is switched over the microcontroller.

Using the above requirements as our design criteria, we were able to successfully select required parts to achieve function status of the plane. From there we designed the required circuitry for the plane while waiting for the required parts to arrive. Using the circuitry, we designed the PCB required for the plane. Upon receiving the PCB, we began populating the PCB, testing important modules while as we proceeded. After that the software was developed. Finally the product was tested based on our PSSCs.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The project successfully ties everything we have learned together in the earlier ECE coursework. It used skills from basic circuit design to knowledge of programming microcontrollers. For example,

designing the circuitry for the power supplies required knowledge of Buck converters and how to efficiently utilize them. Also, programming the microcontroller required knowledge of how to program using Codewarrior effectively.

For the circuit designing aspect of the project, we utilized skills that we acquired from ECE 201, 202, 207, 208, 255 and 270. They provided the basic necessary skills to analyze the required circuitry and develop the circuitry and PCB. Classes such as ECE 362 helped facilitate the knowledge needed to program the software for the plane. They provided experience in C programming which is the language used in Codewarrior.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The team learned how an RC plane system works and how the different parts interacted with the radio control unit. We also learned how to fly an RC plane and how to properly balance the plane. This ended up being a very important issue.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

First the team had to agree on a mutually acceptable project. After that, the team had to consider the constructability of the project and designed the project. We also viewed existing designs and evaluated previous team designs for ideas on how to design the project. The team then had to decide on what were the success criteria that the project should achieve. Each team member suggested success criteria and their practicality were evaluated democratically.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Since the project qualified for very few free sample parts, most of the parts had to be purchased. This placed a relatively tight constraint on the budget since most parts for the project was relatively pricey. Each member of the team ended up purchasing a specific item for the project. The team selected parts that could fit our criteria and would cost as cheap as possible. Parts that cost the most such as the model RC plane, the new engine, the new battery and radio controller were all evaluated for value. Fortunately, the radio controller was donated by a member of the local RC club.

Environmental: The product has a relatively large environmental impact during production and end of life. During the production phase, many pollutants are released. These pollutants must be properly treated before released back into the environment. To reduce the carbon footprint left by the product, the product is designed with mostly recyclable parts.

Ethical: The plane can be used for unethical purposes such as spying on people or military installations. Although the product has no safety features to bypass this. A production level product will have to include some software to protect the end user from doing anything unethical. This was considered during the engineering phase but due to timing constraints was eliminated.

Health & Safety: Due to the high level of toxicity of the onboard lithium battery, the battery must be disposed properly. Lithium is known to cause blindness and can be fatal if ingested. If the batteries are not disposed properly, there is a possibility that the lithium compound might seep back into groundwater supplies. This could cause harm to people and therefore as an incentive, the product will have to incorporate an incentive to properly dispose of the battery. Furthermore, the volatile

nature of the battery means that it has the tendency to explode if provoked. As such the user can be hurt if the battery is damaged during midflight. Therefore the battery should be located in the safest part of the plane. Also in order to resolve possible Lead issues, we have elected to use RoHS compliant parts and PCB manufacturing.

Manufacturability: To facilitate the manufacturability of the product, most of the parts are available off the commercial market. We opted not to use many custom parts to reduce the need for manufacturing on our part. For example, the additional structure that houses the camera is constructed out of foam that is easily available.

(f) Description of the multidisciplinary nature of the project.

The construction of the plane required the management of weight, aerodynamics and balancing of the plane. To ensure success of the product, we had to ensure that the plane had enough lift for its weight. This required some mechanical knowledge and we enlisted the help of a ME to help facilitate the process. Also, to maintain the aerodynamic shape of the plane after modification, the shapes of the add-ons have to be accounted for.

(g) Description of project deliverables and their final status.

The final product should be an RC plane that is capable of autonomous flight. The plane should be able to access a microSD card to acquire the necessary waypoints. The plane should also be able to interface with a GPS module to acquire current coordinates and data. Furthermore the plane should be able to control the ailerons, rudder and elevators of the plane. The plane should also be able to trigger the onboard camera module. Currently, the plane is able to interface with a GPS module, access a microSD card, trigger the onboard camera and control the flight mechanisms. As of the moment the plane is currently not flyable due to signal interference of an unknown source.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	11
Project Title	RoboRubik

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Erik Carron	ECE	Hardware Development	May 2008
Dave Bukiet	ECE	Device Communications	May 2008
Tyler Heck	ECE	Packaging/Hardware	May 2008
Casey Kloiber	ECE	Software Development	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

RoboRubik is a self-contained Rubik's Cube solver consisting of a microprocessor-controlled PCB with multi-colored LEDs under each cube face. A user interface is used to input the current state of the cube via an embedded web server. A stored algorithm calculates the moves required to solve a Rubik's Cube from any valid starting position. The cube has two different mode of operation. Help mode allows the user to follow the steps leading to the solution with RoboRubik acting as a visual aid. Play mode gives the user the ability to solve the RoboRubik cube manually using buttons located on each cube face.

The proposed customer of RoboRubik is anyone who is interested in the Rubik's Cube, from beginners who don't know how to solve the cube to experts who have a long standing interest.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

RoboRubik expands greatly on previous knowledge in ECE. An understanding of digital logic from ECE 270 as well as simple circuitry was necessary for the completion of the project. ECE 362 was a major factor in preparing us for this course. Knowledge of the different subsystems of a microcontroller was imperative and helped greatly.

The creation and modification of the user interface was dependent upon the group's knowledge of Java as well as networking and serial communications.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The main skill acquired during this class was the knowledge of how to create a PCB layout as well as how to work with digital hardware. Creating a PCB layout required a large amount of research but it is a skill that will be useful in the future. Soldering was also a new skill added to the groups

understanding. A number of different components were soldered during the completion of the project.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first step was to create a project outline and determine what the goals of the project would be. This was accomplished in the second homework by creating the five project-specific success criteria. We created block diagrams and subsequently schematics of RoboRubik. Analysis of all components was required before we could finalize the schematic and move onto PCB design.

Once the schematic and PCB layout were complete, construction could begin. The PCBs were populated with their components when they came back from fabrication. We started testing the side PCBs individually to ensure that they would light up correctly and could receive the correct data from the microcontroller. Once that was complete the main board was finalized and coding began. More testing of code on the main board came next. Once that was complete we tested the entire system together.

After working through any remaining bugs, the last step to evaluate if we had passed all five of our project-specific success criteria. We found that we did pass all five and moved onto packaging the project. This was the final step in completion of RoboRubik.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: We strived to acquire the cheapest parts available while still meeting our functionality requirements. This would ensure that the project would not be expensive.

Environmental: We made sure to use as many parts of possible that were RoHs compliant as well as components that would conserve energy.

Ethical: We strived to make RoboRubik as safe as possible, using components we knew were safe and reliable.

Health & Safety: We strived to include warnings and safety documentation as to the proper use of the project.

Social: We took a well known product, the Rubik's Cube, and updated it for the 21st century.

Sustainability: We performed reliability tests and determined that RoboRubik is a safe and reliable device.

Manufacturability: Our design is unique and requires the creation of seven PCBs for each product. During manufacturing we would strive to be an environmentally friendly as possible.

(f) Description of the multidisciplinary nature of the project.

A number of different disciplines were used in this project. Of course, electrical and computer engineering was used in the creation of RoboRubik. We also used some civil engineering skills in the

creation of the packaging and design of the housing. Some non-engineering skills were also used, namely correct technical writing skills and presentation skills.

(g) Description of project deliverables and their final status.

The final deliverable in RoboRubik, fully encased in its plexi-glass housing. It consists of seven PCBs in total, one main board and six side boards to represent all the colors of a Rubik's Cube. The cube has an internal web server for accessing the user interface which can be accessed through a wireless network connection.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	12
Project Title	The Two Wheel Deal

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Pete Dudash	EE	Software/Packaging	May 2008
Greg Eakins	EE	Electromechanical Interfacing/PCB	May 2008
Eric Geier	EE	Software/Interfacing	May 2008
Jeremy Gries	EE	Hardware/PCB	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The Two Wheel Deal is a compact, two wheeled, and self-balancing personal transportation device. It works on the inverted pendulum control theory. It is powered by two 12 volt, sealed, lead acid batteries tied in series, and it is driven by two brushed, DC motors that are geared down. Each motor is controlled independently using H-bridges that are fed PWM signals from the microprocessor. The PWM signal is determined using a PD controller which takes readings from an accelerometer and a gyroscope. The accelerometer reads the angle the vehicle has tilted from vertical and the gyroscope reads the rate at which the vehicle is rotating. The rider can move the vehicle forward and backward by leaning forward or backward respectively. The vehicle can be turned using a joystick located near the handle bars. Data such as speed, angle, and battery life are displayed to the rider on an LCD.

The purpose of the Two Wheel Deal is to serve as an economical and practical alternative to most forms of short range transportation, including cars, bikes, and walking. The target customer is anyone who wants a little more excitement or fun on a typical everyday walk or adventure or anyone who would like some relief from long hours of walking. The vehicle can be used by businesses in industrial settings for traveling throughout a plant, or for policing a mall. It can also be used recreationally in parks and trails. Having only two wheels gives The Two Wheel Deal a small footprint for enhanced mobility over conventional means of transportation.

The idea for the project stemmed from a mutual interest in control theory and motor control. An initial idea proposal consisted of variants on the autonomous robot/vehicle that could travel from point to point using GPS. This type of project had been done quite often though so while searching for different ideas, we came across a project where a group made a miniature, self-balancing robot. This appealed to everyone in the group, but we wanted to take it one step further and create a full-size vehicle similar to the Segway. The first step toward completing the process was to research similar self-balancing projects as well as all of the theory and design considerations behind every part of the vehicle. We were able to use some of the advice and major components used by the other people to aid in the selection of components for the Two Wheel Deal. It was decided that the motor controllers would be built from scratch due to the huge cost of commercial controllers. This part was

heavily researched to prevent a catastrophic failure due to the high current requirements of the circuit. Samples and parts were ordered and the schematic was started on both the microcontroller board and the motor controller boards. The initial PCB layouts were then created as well as a Bill of Materials. The schematic and PCB layout were continually refined (and at one point, entirely redesigned based on feedback from the course staff) in the week or so after the initial design. The software was then started and an initial draft was completed about the same time the PCBs were finished. Each board was populated one part at a time and a logical sequence of debugging was performed during the build up. Once the chassis and electronics were complete, testing and debugging was performed until the vehicle behaved nearly optimally.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

This project built upon extensive knowledge and skill acquired throughout ECE coursework. One of the most important courses was ECE 382 where knowledge of how a PD controller works and is implemented was learned. The PD controller is the main algorithm that keeps the Two Wheel Deal stable and controllable. Another crucial course was ECE 362 where microcontroller design and interfacing was learned extensively as well as how to read datasheets. A great number of design considerations (accelerometers, part selection, and power consideration, scope of project) were learned during the mini-project in ECE 362 that carried over to this project. Also, the mini project helped prepare the group for a long term design project that was started with nothing except an idea. PLD knowledge learned in ECE 270 was used in the project to create the combinational logic that converts the microcontroller outputs into meaningful inputs to the motor controllers. Basic circuitry knowledge learned in ECE 201 was crucial in helping determine how much current would be flowing through the boards to determine how big the traces must be to ensure they would not burn up. This knowledge also helped when designing the schematics. Knowledge of how a brushed, DC motor is controlled and modeled, which was learned in ECE 321, came in use when understanding and designing the four quadrant chopper (H-Bridge). CS 158 and ECE 264 provided extensive knowledge of how to program using C.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

The most important new technical knowledge or skill acquired while completing this project was how to design and create a PCB layout. The software had never been used before so that took some time to understand how to do the necessary operations. Also, no team member had designed a PCB before so there were considerations such as placement of certain components, how to lay traces, and minimizing vias that were learned as the board was completed. Another technical skill acquired was how to determine which parts to use in the project. There are so many different types of the same hardware component so knowing which component will work that doesn't have a lot of overkill is important in industry. Learning to use AVRStudio4 and an Atmel chip was another technical skill acquired during this project. Previously, the only microprocessor work that any team member had done was on a Freescale chip so the new software and interfaces had to be learned. Learning how to keep a good lab notebook and work in a team environment were also good skills learned throughout the course as well as how to give technical and non-technical presentations.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

To establish the objectives and criteria for the project, the team determined what the most crucial parts of the project were and used these to create the five Project Specific Success Criteria. This included things such as independently controlling motors, ensuring some safety features, displaying

data to the rider, balancing autonomously, and navigating through tilting and use of a joystick. This is what was used to determine whether the project would be a success or failure. Next, a basic block diagram was made that showed all the crucial parts such as the microcontroller, motor controllers, motors, LCD, joystick, and batteries. Analysis then began by researching various options for the hardware choices. Each choice was carefully examined and the most efficient components with the least amount of overkill (but with a substantial safety margin) were selected. These components were used to create schematics and PCBs which helped to ensure the synthesis of all the parts. Construction began with the return of the fabricated PCBs and the assembly of the vehicle chassis.

The vehicle dimensions and material had been determined during the analysis stage, and materials were cut and created throughout the semester. Testing occurred at both a hardware and software level. Hardware testing occurred as the PCBs were populated. One group of components such as the power components would be added then thoroughly tested to ensure there were no issues. The motor controllers were tested using only one FET per leg and the minimum support components. Once the testing was complete, a new block of components would be added and tested. Software testing and debugging occurred almost entiresly through the LCD interface. It was the first component successfully implemented. As code modules were written for the rest of the project, data was output to the LCD to ensure the correct numbers or values were being calculated. The project was evaluated at the end of the semester by assessing whether the Project Specific Success Criteria were completed and whether any additional features could be added in the amount of time that was left.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: Some economic constraints included designing and building H-Bridges from scratch rather than purchasing commercial ones to save money. Also, having the motors, steel hubs, and some metal used on the chassis donated helped to lower the project cost. Finally asking for samples of hardware components rather than purchasing them kept the out-of-pocket cost low.

Environmental: Some environmental constraints included choosing parts that are RoHS compliant. Also sealed, lead acid batteries were chosen since they can be recharged to reduce the amount of battery waste due to the vehicle.

Ethical: Since the Two Wheel Deal can easily hurt a rider if it is not operated correctly, a training DVD and session would be offered if the vehicle was ever sold to anyone. Also anytime a student asks to ride the vehicle, a team member is always present to train the new rider as well as give him/her tips on how to operate it most efficiently. Finally, a user manual has been created that helps answer any questions a rider may have as well as provide warnings on what not to do with the Two Wheel Deal.

Health & Safety: The most important safety constraint on the Two Wheel Deal is that the wheels shut off once the vehicle reaches a certain tilt angle. This helps to ensure the rider is not run over or hurt even more if he/she happens to fall off the vehicle. Other safety considerations include placement of warning labels in areas that can harm the rider such as near the battery connections or spinning fans on the motor controllers.

Social: This is a socially redeeming project. It was created as an efficient alternative to driving short distances in a car or walking. It can also be used as a more fun alternative to riding a bicycle or skateboard. These constraints were kept in mind throughout the project design.

Political: One main political constraint is to create an efficient and fun vehicle that will help persuade politicians to seriously start considering alternate forms of power for vehicles.

Sustainability: One sustainability constraint was to ensure the vehicle would still operate regardless of possible vehicle crashes. The chassis was designed around protecting the batteries and the electronics. The vertical shaft protrudes past the vehicle platform in order to protect the PCBs at the front of the vehicle, and metal protectors are placed on the front of the batteries to prevent them from being scraped on the ground. All of the PCBs are securely mounted behind the side rails and underneath the main platform for protection.

Manufacturability: A major manufacturing constraint was to assemble and package the project in a way that could easily be created without too much mechanical experience. Since this was an Electrical Engineering project the focus was on the electronics rather than the appearance or materials used. If the vehicle would be mass produced, it would probably be made out of a more user friendly material that didn't have as many razor sharp corners and could be made quickly and efficiently on some sort of assembly line.

(f) Description of the multidisciplinary nature of the project.

The major concepts present in this project are Electrical and Computer Engineering. The main control algorithm is based on the inverted control theory and a PD controller. This is a strong Electrical Engineering concept, but is also used by all sorts of engineers. Another strong Electrical Engineering concept is the DC motor control performed using two four quadrant choppers (H-Bridges). Since the heart of the vehicle is a microcontroller, Computer Engineering plays an important role. Mechanical Engineering concepts are also present through the design and manufacturing of the steel wheel hubs as well as the overall packaging of the vehicle. Knowledge of basic physics aided in understanding the nature of the inverted pendulum, as well as the data received from the sensors. Non-engineering skills are also present. Project management skills were important in ensuring major obstacles were overcome in a timely manner to help guarantee the project would be finished by the deadline. General writing skills and communication skills were used and developed throughout the semester during the homework and technical presentations. Ergonomics were also considered when determining where the joystick and handlebars would be located.

(g) Description of project deliverables and their final status.

The deliverable project is the Two Wheel Deal vehicle. It consists of a metal platform with a vertical shaft connected to the front. At the top of the vertical shaft, a box is mounting containing the LCD, rider/no rider switch, and the steering joystick. The handlebars are mounted underneath the box. The LCD displays the tilt angle, vehicle speed, and battery life. The vehicle has two sealed, lead acid batteries and two brushed, DC motors under the platform. The steel hubs and wheels are attached to the motor shafts. Also under the platform are two motor controller boards and a microcontroller board. Everything is accounted for and working except the LCD which was broken during testing and debugging.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	13
Project Title	Touch 2 Order

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Srichand Yella	EE	Hardware design and debugging, wireless interfacing	May 2008
Anvesh Dasari	EE	Software, Peripheral Interface	Dec 2008
Varun Vallabhaneni	EE	Hardware Design, Power Systems and Packaging	May 2008
Madhu Tummala	EE	RF communications, Software and Soldering	May 2009

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The 'Touch 2 Order' is a portable device exclusively designed for use in restaurants. The user can order food from the comfort of his table and also pay for it using RFID card. The order is wirelessly transmitted to the server in the kitchen. The device consists of a touch screen display where the menu of the restaurant is displayed. The user can select items just with a touch on the screen. The items are automatically added into the cart. The display is 8.7 inch LCD screen, it uses Zig Bee interface for wireless transmission and a spark fun ID-12 RFID reader. The core of the system is a Freescale MC9S12E128 microprocessor.

The design started with selection of components and connecting the circuit through a schematic. The PCB is then designed with the help of the schematic. The microcontroller and LCD screen were coded using Code Warrior and Hyper Terminal respectively. After the successful working of the device it was packaged to finish all the objectives of the Digital Systems Senior Design Project.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Purdue ECE curriculum is the base for our knowledge and skills we used in completing this project. The main course that formed the core for our project was ECE 362 Microprocessor Interfacing. We learnt about microprocessors in this course which was the core of our project. Other courses on semiconductors also helped us in knowing the working of MOSFETS and other semiconductor device components we used on our PCB. Apart from digital there were also analog circuits in our design which we learnt through courses such as Linear Circuit Analysis etc. Although we learned

many new things while doing this project other courses we learnt at Purdue were very helpful in various stages of our design which led to its completion.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

Many new skills such as advanced use of Orcad Capture, PCB Layout using Layout Plus, soldering were required to be learnt for hardware design and software such as Code warrior and Hyper terminal were needed for coding the microcontroller and LCD screen. Although we learnt much of it on our own the course staff was also very helpful.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first step after we finalized our project is to define the success criteria for our project. Some of our criteria were rejected as they were considered similar. So we had to analyze again and added some features to add more success criteria. Then we did a lot of research on the component selection. This was a tough job as some of the components are expensive and we cannot change them over and over, it took a lot of time to select the perfect components we needed. Then it was the synthesis part where we used Orcad to construct the schematic off the whole design and designed the PCB Layout using Layout Plus. We initially got many errors. We went back to the schematic fixed those errors and redesigned the PCB Layout as it is the most important part. One error in the PCB can cause the device not to work. Once we got our PCB we populated them with the components, the software was done for the microcontroller and LCD screen. It was time for testing. This was the time when we needed to fix a lot of things like using level translators in between. After successful testing the Project Specific Success Criteria were demonstrated to the course staff and were approved.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The most important consideration for our project is economic as there is no funding for the project, it is important that we don't go overboard and make the product really expensive. Although we spent a lot for the project we also minimized some unwanted features to make it cost effective.

Environmental: It is an important challenge to make it environmentally friendly. Although we used many components that are harmful to the environment if they are not disposed properly, we provided the required guidelines regarding the measures to be taken to make the product environmental friendly during its various stages of life cycle.

Ethical: Ethically we took enough measures to take care of the safety issues that arise due to security reasons concerning RFID and wireless communications.

Health & Safety: Our device is designed keeping the health and safety issues in concern. There would be no potential for damage to the user while handling this product. Enough safety measures are also provided which are required while dealing with battery leakage issues.

Social: The interactive touch screen is designed so that the navigation is very user friendly and it doesn't take much time to understand how to use the product.

Political: Although our device is similar to many products that are patented earlier, the basic purpose is entirely unique. Any potential for infringement can be taken care of by licensing with the owner of the patent.

Sustainability: The reliability and safety analysis done on the device proved that the sustainability of the product is really high concerning all the issues that were mentioned in the military handbook in the course website. The packaging is done in a way that it is durable and can withstand all kinds of harsh usage.

Manufacturability: The manufacturing of this product is not a big issue. There are not many problems associated with it. Once the specifications are given to a manufacturing company there wouldn't be any problems concerned with manufacturing.

(f) Description of the multidisciplinary nature of the project.

Many other skills other than those acquired in ECE were also utilized in the project. First and foremost leadership skills were required to form a team and decide on a single project provided each one has many ideas. They are also useful in deciding on the components and fixing the team meetings and making sure everyone attends. Homeworks such as the User Manual provided some idea on marketing skills. Technical and professional writing skills were also required in completing the documentation for the other homeworks. Mechanical skills were required for soldering and packaging of the product. So apart from the core ECE knowledge a lot of other things were also needed to finish the project.

(g) Description of project deliverables and their final status.

The final packaging of the product is done. All the PSSC's were successfully demonstrated. The final report, both soft and hard copies, a CD with the project website archived and project poster are being submitted along with this report. The final demo and presentation are also ready to be presented at the appropriate time allotted.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	14
Project Title	SmartGlove

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Donghan Ryu	CmpE	System/Software Design	May 2008
Yukeun Sim	EE	Circuit/Electrical Design	May 2008
Shiv Biddanda	EE	Application Development	May 2008
Po-Cheng Wang	CmpE	Peripheral Integration	May 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

The mouse is currently used as a method to interact with the computer. However, the mouse has many limitations that limit its use. One good example would be that the mouse can only be used on large flat surfaces. The SmartGlove is an innovative human interface device that runs on any surfaces. It is glove shaped device wearable on the right hand. The SmartGlove functions and operates like the touch-pad seen on most laptop computers. However, it is much more advance then the average touch-pad. The SmartGlove can perform basic mouse commands such as moving of the mouse cursor, left/right clicking, and scrolling just like a regular touch-pad. Additional multi-touch features are also possible through the SmartGlove. Since the SmartGlove is meant to be an alternative to the mouse and touch-pad, all current computer users are potential customers.
The device will communicate with the computer using Bluetooth and functions like a regular mouse/touchpad. This is done by attaching accelerometers and pressure sensor to the tip of each finger. Using the sensors placed on the glove, the SmartGlove is able to convert finger movement and finger tapping into different functions. By detecting different finger movements and finger tapping, various functions such as cursor movement, scrolling, and button clicking can be achieved.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

The main course that prepared us for this project was ECE362. It taught us many skills that were used in the project. These skills include how a microprocessor works, how to use on-chip peripherals, the interrupt control system, and microcontroller programming. All the skills learned in ECE362 were usable for our project right away. Other classes such as ECE270 taught us how to use state machines which was helpful in programming user gesture input. ECE201, ECE202, and ECE255 taught us how basic circuits work and how to build circuits with diodes and amplifiers.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

PCB design and layout was the main new technical skill acquired while working on the project. In combination with PCB design was learning the importance of reading documentation. The documentation of various components used on the PCB can help solve problems and save time while designing the PCB. Soldering was also a new skill acquired. Although soldering was also used in ECE362, soldering surface mount device was a new experience.
Learning how the legal system works regarding patents and safety concerns was also important. This taught us the importance of making a reliable and innovative product when it is to be sold commercially.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

The first step to creating this product was to come up with an objective and establish the success criteria. This was done in homework 2 where we had to propose five project specific success criteria. The next step was to analyze what needed to be done for the project to succeed. We did this by creating block diagrams of components that would be needed for the project. To synthesize the block diagrams, we created schematics for each block diagram of the product. Then, we create PCB layouts from the schematics. Construction of the product was the next step. Once we received the fabricated PCB, we soldered all the components to it. After the PCB was populated with components, we started testing the PCB. We loaded code into the microprocessor and began testing the various functions of the PCB. Some fly wiring and trace scratching was done to fix the problems on the PCB. One the PCB was working, we started to test the SmartGlove using the computer. A Windows XP program was written to proper communicate with the device. When testing was complete, we moved to the last step, which was evaluation of our completed product. We were able to meet all five project specific success criteria that we proposed in the first step.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: We used low cost components that fit our needs. This allowed the project to be cheap to the consumers.

Environmental: We used RoHS compliant components for our project to address the environmental concerns. Lithium polymer battery disposal instructions will also be included with the product so that users will know that to do when the product reached to end of its life.

Ethical, Health & Safety: Our product has the potential of exploding due to the use of a lithium polymer battery. Future iterations of this project will include more safety circuits to help prevent disaster. Warnings will also be included in the user manual.

Social: The main idea of the SmartGlove is to provide a cheap alternative to the mouse and touch-pads used on computers today. Advantages over the mouse and touch-pad include the functionality of multi-touch gestures and the ability to work on any flat surface.

Political: There are no political considerations that affected the design of our project.

Sustainability: We performed a reliability analysis and concluded that our product had a reasonably long life span. Calculations indicate that it has a mean time to failure of 70,000 hours.

Manufacturability: If our product was to be manufactured, we would refine the glove so that wires and sensors will not be visible to the user. After addressing these concerns, the product should have few problems in manufacturability.

(f) Description of the multidisciplinary nature of the project.

The main skills required to complete this project can be learned from electrical engineering and computer engineering. Some mechanical engineering skills are required to design and create the packaging. Non-engineering skills are also needed. Skills such as marketing and communication are needed to help brand and promote the product. Technical writing skills are also required to create the documentation.

(g) Description of project deliverables and their final status.

The deliverables of this project is the SmartGlove. This includes a glove, an arm module, and a program runnable on Windows XP. The glove consists of a glove with sensors attached to the thumb, index, and middle finger. Each finger has two sensors attached, a force sensor located at the tip of the finger tip; and an accelerometer, also located on the back side of the finger tip. All sensors are attached to wires which come together to form a ribbon cable. The arm module consists of the PCB, Bluetooth module, and lithium polymer batter all cased in a black plastic box. The box has straps that can be used to strap the arm module to the arm. The arm module has two connectors, a USB connector is located on the side of the box for recharging the battery; and a regular connector is located next to the USB connector so that the ribbon cable from the glove can be connected to the arm module. The program is used to initiate communication between the SmartGlove and the computer. All parts of the SmartGlove are operational.

Purdue ECE Senior Design Semester Report

Course Number and Title	ECE 477 *Digital Systems Senior Design Project*
Semester / Year	Spring 2008
Advisors	Profs. Meyer and Johnson
Team Number	15
Project Title	VDAR

Senior Design Students – Team Composition			
Name	**Major**	**Area(s) of Expertise Utilized in Project**	**Expected Graduation Date**
Miles Davis	CompE	Embedded software, hardware-software interfacing, networking, motorsports	May 2008
John Hubbard	EE	Wireless technology, sensor technology	December 2008
Ryan Rearick	EE	Wireless technology, power systems	May 2008
Nick Novosel	EE	Sensor technology, hardware design	December 2008

Project Description: Provide a brief (two or more page) technical description of the design project, as outlined below:

(a) Summary of the project, including customer, purpose, specifications, and a summary of the approach.

VDAR (Vehicle Data Acquisition for Racing) is a wireless data acquisition system designed for kart racing. As long as there is room for the junction box, VDAR is compatible with virtually any type of kart. This makes VDAR a smart buy for anyone from beginning drivers to veterans. Its purpose is to improve kart performance through identifying mechanical problems or driver errors in real time during a practice or an actual race. The junction box for VDAR is 10” x 8” x 3” and weighs around 4 pounds. It measures several important aspects of the kart including steering and throttle position, fuel level, engine and exhaust temperature, RPM’s, and speed. The wireless antenna has a range of approximately 300 feet.

Our approach started with testing the pulse train sensors to determine their output. We then prototyped the analog circuits with our development board. The design of the schematics was largely based on manufacturer’s data sheets. After laying out the PCB, we tested each block (power, analog, etc.) of the board as its components came in. Once the PCB was debugged, the software was written and implemented on the PCB’s microprocessor.

(b) Description of how the project built upon the knowledge and skills acquired in earlier ECE coursework.

Basic circuit analysis from ECE 201 was used to design, test, and debug the PCB. Our knowledge of multiplexers from ECE 270 allowed us to implement two of them into our PCB. Finally, much of our knowledge of the HCS12NE64 microcontroller was derived from ECE 362. This includes how to use the development kit for the NE64 and several of the peripherals such as ATD, SPI, and the timer module.

(c) Description of what new technical knowledge and skills, if any, were acquired in doing the project.

One technical skill we all learned was how to layout a PCB using OrCAD. None of us had any experience with it whatsoever before the start of the project, so acquiring this skill was difficult and frustrating at times. Another skill we acquired was soldering a component such as the NE64 to the PCB. This was challenging because it has several small pins spaced very close together. Finally, we learned how to develop a web server on a microcontroller using OpenTCP.

(d) Description of how the engineering design process was incorporated into the project. Reference must be made to the following fundamental steps of the design process: establishment of objectives and criteria, analysis, synthesis, construction, testing, and evaluation.

Our design process started with establishing our five objectives, the PSSC's. Based on our PSSC's, we analyzed the sensors and microcontroller that we planned on incorporating into VDAR. From this analysis we determined several important aspects of our project, including which peripherals would be used on the NE64 and most of the individual components for the PCB. Schematics for each block of our PCB were then created after analyzing the manufacturer's data sheets for each of the selected components. The synthesis step of the design process naturally followed all the analysis. Using OrCAD's layout system, the different schematics were all combined into one PCB design. After that was complete, the construction and testing of the PCB began. As components for the PCB came in, we soldered them onto the board. When an entire block of the board was populated, it was tested for functionality. At the same time, construction of the hardware began now that we knew how big the junction box had to be based on the size of the PCB, batteries, and wireless router. Once the junction box was completely constructed, the wireless router's range was tested. Finally, the code to transfer data from the NE64 to the host computer and the code to display the data on the host computer was written and tested.

(e) Summary of how realistic design constraints were incorporated into the project (consideration of most of the following is required: economic, environmental, ethical, health & safety, social, political, sustainability, and manufacturability constraints).

Economic: The goal of the project was to keep costs to around $200/person ($800 total). This was based on the fact that this is about the average cost of a commercial data acquisition system. Also, no one in VDAR has a personal budget that could handle more than a $200 expense for senior design anyway. If VDAR is used correctly and proper analysis of the data is taken, the increased kart performance could save the driver and crew money.

Environmental: The main environmental concerns of the project involve the manufacture and the disposal of the PCB as well as the NiMH batteries. The manufacturing process for PCBs involve heavy metals and acids that need to be contained and disposed of properly by the manufacturer. The PCB should be dropped off at any electronics recycler to ensure the lead and any other heavy metals in the PCB do not get released into the environment. NiMH batteries are considered "environmentally friendly" and ideally should be recycled with the electronics but do not pose a serious threat if disposed of in normal trash.

Ethical: There are very few ethical concerns involved in the usage of the VDAR. The RF radiation given off does not pose a threat to the driver at the power levels the VDAR uses and there is not legitimate concern for the VDAR to cause any sort of physical harm to the users. The main concern of the race team should be not counting on the unit as the only way to acquire data. Since VDAR does not communicate with the driver this scenario is unlikely and should not be a problem but if it were to malfunction in a race in a mission critical type of installation it could cause the loss of a race.

Health & Safety: VDAR has is a very low health and safety risk since it is just taking measurements and not involved with the running of the kart. Still, health and safety risks that we could identify were reduced as much as possible. The largest risk involved the batteries overheating or exploding, so we chose to use nickel-metal hydride because they are known to be very robust and stable.

Social: VDAR was not designed to be used in favor of certain drivers or crews over others and it does not break any government codes.

Political: VDAR's PCB (not including the components) was funded by Purdue University. The rest was privately funded by the members of group 15.

Sustainability: Under normal operating conditions, VDAR has a life span of 10-20 years. The junction box is aluminum to block out the significant amount of EMI produced by kart engines. Also, all the components in VDAR were chosen to handle the high operating temperature that will exist in the junction box and around the kart. Finally, to reduce vibration, the batteries were packed with foam and both PCB's were securely mounted to the inside of the junction box. Securely fastening the junction box itself to the kart will also help reduce vibration.

Manufacturability: All hardware in VDAR is readily available through the manufacturer's website or a local electronics store. The software will be available on VDAR's website. The junction box is customizable in that it can work with several more analog and digital sensors. Plus, it can be placed anywhere there is room on the kart. Finally, the outside of the junction box is ready to be painted or decaled at the preference of the driver or crew.

(f) Description of the multidisciplinary nature of the project.

VDAR used electrical, computer, and mechanical engineering skills. Electrical engineering knowledge was used to design and test the PCB, and connect the main PCB, to the wireless router and the wireless router to the host computer. Computer engineering skills were used to write the software that allowed data to be transmitted from one to the other and finally displayed on a java applet.

(g) Description of project deliverables and their final status.

The project deliverables include this ECE senior design report, a hard copy of the final report, and an archive CD of our website. The final report includes all of our updated homework that has been completed throughout the year.